Facultad de Química
Universidad de la República

Application of sensory methodologies to the development of functional foods

Gastón Ares Devincenzi

Directed by Dr. Adriana Gámbaro and Dr. Rosires Deliza

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‘Develop a passion for learning. If you do, you will never cease to grow’

Anthony J. D’Angelo

ABSTRACT

The general objective of the thesis was to apply and study different sensory methodologies in the development of a functional food product.

The thesis was divided into three main parts: the study of Uruguayan consumers' perception of functional foods, the study of antioxidant extracts from Uruguayan native plants as functional ingredients, and the development of a functional food enriched with antioxidants.

In the first part of the thesis Uruguayan consumers' perception of functional foods was studied through the application of different methodologies (surveys, laddering, word association and conjoint analysis). Results showed that Uruguayan consumers had a positive attitude towards functional foods. In particular, consumers were interested in dairy desserts and yogurts enriched with antioxidants. The way in which the addition of the functional ingredients was declared and the use of health claims had a high impact on consumers' interest in these functional products.

Next, the sensory profile, the polyphenolic content and radical scavenging capacity of three solvent extracts (water, ethanol and acetone) of three Uruguayan native plants (*Achyrocline satureoides*, *Baccharis trimera* and *Mikania guaco*) were evaluated. Due to the intense bitterness, astringency and characteristic flavour of the extracts, alternatives to reduce these flavours were studied: sucrose, sucralose, polydextrose, milk and flavourings. Results suggested that sweetened chocolate dairy products could be interesting carriers for the development of functional foods containing polyphenolic-rich antioxidant extracts from *Achyrocline satureoides*.

Using different methodologies, such as projective mapping, open-ended and check-all-that-apply questions and external preference mapping, a formulation of a regular chocolate milk dessert that showed high consumer acceptance was selected. Using this formulation as carrier product, chocolate milk desserts enriched with a water extract from *Achyrocline satureoides* were developed. Considering consumers' overall liking scores, the maximum concentration of the antioxidant extract from *Achyrocline satureoides* to be added to chocolate milk desserts corresponded to a polyphenolic concentration of 0.4 g/L. This product could reach an interesting market since a relatively high proportion of consumers chose it over a regular chocolate milk dessert. Therefore, the development of this type of functional food could be an alternative for Uruguayan dairy companies to launch to the market differential products with added-value.

All the evaluated methodologies proved to be extremely useful during the development of a functional food product. They could be used in the development of food products in order to better take into account consumers' wants and needs, which could increase the success of new food product development process.

RESUMEN

El objetivo general de la tesis fue la aplicación y el estudio de metodologías sensoriales al desarrollo de un alimento funcional.

La tesis se dividió en tres grandes partes: el estudio de la percepción de alimentos funcionales por parte de consumidores uruguayos, el estudio de extractos antioxidantes de plantas nativas uruguayas como ingredientes funcionales, y el desarrollo de un alimento funcional enriquecido con antioxidantes.

En la primer parte de la tesis se estudió la percepción de consumidores uruguayos de alimentos funcionales mediante la aplicación de distintas metodologías (encuestas, laddering, asociación libre y análisis conjunto). Los resultados de los estudios realizados indicaron que los consumidores uruguayos tienen una actitud positiva hacia los alimentos funcionales. En particular, los consumidores estuvieron interesados en postres lácteos y yogures enriquecidos con antioxidantes. La forma en que se declara el agregado del ingrediente funcional y la utilización de declaraciones sobre efectos en la salud tuvieron un elevado impacto en el interés de los consumidores en estos productos.

Luego, se estudió el perfil sensorial, el contenido de polifenoles y la capacidad de secuestrar radicales libres de tres extractos (acuoso, etanólico y acetónico) de tres plantas nativas uruguayas (*Achyrocline satureoides*, *Baccharis trimera* and *Mikania guaco*). Debido a la elevada intensidad de amargor, astringencia y sabor característico de los extractos, se estudiaron alternativas para reducir estos sabores: sacarosa, sucralosa, polidextrosa leche y saborizantes. Los resultados indicaron que productos lácteos dulces sabor chocolate podrían ser alimentos base interesantes para el desarrollo de alimentos funcionales enriquecidos con extractos antioxidantes ricos en polifenoles obtenidos de *Achyrocline satureoides*.

Utilizando diferentes metodologías, como mapeos proyectivos, preguntas abiertas, preguntas marque todo lo que corresponda y mapeos de preferencia externos se seleccionó una formulación de un postre lácteo de chocolate con una elevada aceptación por parte de los consumidores. Utilizando esta formulación como producto base, se desarrollaron postres lácteos de chocolate enriquecidos con un extracto antioxidante acuoso de *Achyrocline satureoides*. Considerando los puntajes de aceptablidad de los consumidores se determinó que la máxima concentración de este extracto que podría ser agregada a los postres correspondía a una concentración de polifenoles de 0.4 g/L. Este producto podría alcanzar una porción interesante del mercado debido a que una alta proporción de los consumidores lo eligió frente a un postre lácteo de chocolate común. Por lo tanto, el desarrollo de este tipo de alimento funcional podría ser una alternativa para que las empresas lácteas uruguayas lancen al Mercado productos diferenciales con un mayor valor agregado.

Todas las metodologías evaluadas probaron ser extremadamente útiles durante el desarrollo de un alimento funcional. Las mismas podrían ser utilizadas en el desarrollo de alimentos para lograr incorporar en mayor medida las necesidades de los consumidores, lo cual podría aumentar el éxito del proceso de desarrollo de nuevos productos.

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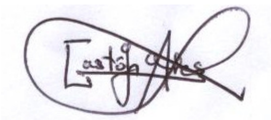

Gastón Ares

LIST OF PUBLICATIONS

The following articles have been published in refereed international journals during the development of the present thesis:

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- Ares, G., Giménez, A., Deliza, R., & Gámbaro, A. (2009). Applications of word association in food product development. Oral presentation at the 8th Pangborn Sensory Science Symposium. Florence, Italy.

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INTRODUCTION

Functional foods can be regarded as foods that beneficially affect one or more target functions in the body beyond adequate nutritional effects, in a way that is relevant to either an improved state of health and well-being or a reduction of risk of disease (Margaret *et al.*, 2002). Functional foods consumption could provide important public health effects, such as decreased mortality and increased quality of life (Siró *et al.*, 2008). Besides, considering consumer interest in foods that positively contribute to their health status, functional foods have become an attractive commercial opportunity for food companies (Mollet & Rowland, 2002). Thus, functional foods offer interesting growth opportunities to food companies by launching to the market differential products with added value.

The development of functional foods has been one of the most intensive areas of food product development worldwide for the last ten years (Biström & Nordström, 2002). Considering the costs associated with scientifically proved positive health effects, the development of functional foods is a complex, risky, expensive and challenging field for the food industry (Urala, 2005). However, many functional food products developed considered only the potential positive influence of specific compounds on health failed when launched to the market; being the rate of failure of this type of food products very high (Hilliam, 1998; Wennström, 2000; van Kleef *et al.*, 2005; Fogliano & Vitaglione, 2005). A better understanding of consumers' perception of functional foods has been recognized as essential for the development of successful functional food products (Siró *et al.*, 2008). By identifying the determinants of consumers' acceptance of functional foods, new food products could be develop to better meet consumers' wants and needs, and therefore, assure their success in the marketplace. In this context, the general aim of the thesis was to apply and investigate different sensory and consumer methodologies in the development of a functional food product.

LITERATURE REVIEW

1. FUNCTIONAL FOODS

Major changes in lifestyle have occurred during the last decade, mainly due to the acceleration of industrialization, urbanization, economic development and market globalization (World Health Organization, 2003). These changes include an improvement on the standard of living, expansion and diversification of food availability, and an increase in the access to services. However, not all the changes in lifestyle are positive as they have also caused negative consequences, such as shifts in dietary patterns and changes in patterns of work and leisure, which have led to a decrease in physical activities (World Health Organization, 2003). These negative changes have often been referred to as the 'nutrition transition'

The qualitative and quantitative dietary changes that characterize the 'nutrition transition' have replaced plant based diets by high fat energy dense diets with an important contribution of animal based foods. These adverse shifts have caused an increase in the energy density of the diet, with a greater consumption of fat and added sugars in foods, an increase in saturated fat intake, a reduction of the intake of complex carbohydrates and dietary fiber, and a decrease in the consumption of fruits and vegetables (World Health Organization, 2002). Such dietary changes are compounded by a shift in lifestyle towards more sedentary patterns, mainly associated with motorized transport, labour saving devices at home, the phasing out of physically demanding manual tasks at work, and leisure time that is mainly devoted to physically undemanding activities (World Health Organization, 2003).

All these changes have had a significant impact on health and nutritional status of populations, leading to an increase of the occurrence of chronic diseases, causes of disability and premature death in both developed and developing countries (World Health Organization, 2003). These chronic diseases include obesity, diabetes mellitus, cardiovascular disease, hypertension, stroke, and some types of cancer. According to the World Health Organization, in 2001 chronic diseases contributed to approximately 60% of the 56.5 million total reported deaths in the world (World Health Organization, 2002), and it has been projected that chronic diseases will account for three-quarters of all deaths in 2020 (World Health Organization, 1998).

In Uruguay chronic diseases are the major cause of death. Cardiovascular diseases and cancer were responsible for 32.9% and 24.4% of the total deaths in 2002, respectively (MSP, 2003). Although most of the total chronic disease deaths are attributed to cardiovascular diseases and cancer, obesity and diabetes are also showing worrying trends, not only because they already affect a large proportion of the population, but also because they have started to appear earlier in life (World Health Organization, 2002). The number of people in developing countries with diabetes is increasing at alarming rates (Wild *et al.*, 2004). Whereas the number of people with diabetes was estimated in 84 million in 1995; it increased to 171 million in 2000 (Murray & López, 1996; Wild *et al.*, 2005). It has been predicted that the prevalence of diabetes for all age-groups worldwide will reach 4.4% in 2030, which accounts for 366 million people (Wild *et al.*, 2004). Furthermore, the current prevalence of overweight and obesity has already reached unprecedented levels and it is increasing at a substantial annually rate in most developing regions (Popkin, 2002).

Along with the lifestyle transitions there has been a major demographic shift (World Health Organization, 2003). The proportion of older citizens has increased in the last decades due to an increase in life expectancy (Shimizu, 2003). Nowadays the relative proportion of people over 65 years in Europe is approximately 17% (European Commission, 2009). This figure is expected to rise to 151 million in 2060; whereas the number of people aged 80 years and above is projected to increase more rapidly: from 22 million in 2008 to 61 million in 2060 (European Commission, 2009). Uruguay follows a similar trend. In 2005 the proportion of people older than 60 years was 18%, whereas 13% of the population was older than 65 years (INE, 2005). In this context, chronic diseases become even more concerning as most of them are observed at the later stagesof life.

The public health implications of this phenomenon are staggering and are already becoming apparent (World Health Organization, 2003). The need for medical treatment is expected to increase, especially among seniors, leading to an increase of health costs (Shimizu, 2003). This will place additional burdens on already overtaxed national health budgets of most countries (World Health Organization, 2003). Therefore, chronic diseases associated with changes in lifestyle represent a great public health burden in terms of cost to society and government (World Health Organization, 2003). Beyond the appropriate medical treatment for those already affected, the public health approach of primary prevention is considered to be the most cost-effective, affordable and sustainable course of action to cope with the epidemic chronic disease worldwide.

Diet has been identified as one of the main factors that can contribute to the prevention of chronic diseases (World Health Organization, 2003). Research has shown that there are certain food components, regarded as non-nutrients, which have biological activities on our body. The consumption of these compounds might be responsible for the beneficial effects connected to some foods and diets, and could help preventing the occurrence of some chronic diseases (Castellini *et al.*, 2002). These non-nutritive components, which are mainly secondary plant metabolites and dietary fibre, are mostly present in some foods in small quantities and have only limited caloric value (Shimizu, 2003). Therefore, the development of foods enriched with these non-nutrients can constitute a way to cope with the chronic disease epidemic.

In this context, the concept of functional foods was developed in Japan in the 80s'. In 1984 the Ministry of Education, Science and Culture of Japan started a research project concerning the role of food on physiological body functions (immune, endocrine, nervous, circulatory and digestive) (Shimizu, 2003). According to this research, foods have three functions. The primary and essential function of foods is satisfying nutritional needs, the secondary is satisfying consumers' sensory needs, and the tertiary is the regulation of physiological body functions (Shimizu, 2003). Thus, a food that has some tertiary function can be regarded as a functional food (Shimizu, 2003) or FOSHU (Foods for Specific

Health use). In 1991 a regulatory system for functional foods was created to stimulate the development of these foods, improve people's health and help overcome increasing cost of health-care (Shimizu, 2003). FOSHU are defined as '*foods which are, based on the knowledge concerning the relationship between foods or food components and health, expected to have certain health benefits, and have been licensed to bear a label claiming that a person using them for specified health use may expect to obtain the health benefit through the consumption'* (Shimizu, 2003).

Japanese interest in functional foods brought awareness about this type of product to the western world (Siró *et al.*, 2008). Functional food products have been lunched in the USA and Europe since the mid 90's (Menrad, 2003). The USA established the Nutrition Labeling and Education Act (NLEA) in 1990. By this act, it became possible to claim that foods or those components approved by the Food and Drug Administration (FDA) may reduce the risk of specific diseases. The Dietary Supplement Health and Education Act (DSHEA) was passed in 1994 and allowed companies to claim that their products have effects on the structure/function of the human body. In 1998, the European Commission Concerted Action on Functional Foods Science in Europe (FUFOSE) and the Codex Committee on Food Labeling (CCFL) proposed two kinds of health claims for functional foods: enhanced function claims, and disease risk reduction claims. According to FUFOSE '*enhanced function claims concern specific beneficial effects of nutrients and non-nutrients on physiological, psychological functions or biological activities beyond their established role in growth, development and other normal functions of the body*' (ILSI Europe, 1999). In the UK, the Code of Practice Assessing the Scientific Evidence for Health Benefits stated in Health Claims on Food and Drink products states that '*if the product is proven to provide a health benefit which can reduce the risk of disease, then it is acceptable to mention the part of the body which may benefit from the reduced risk of disease as long as the disease itself if not stated or implied'* (ILSI Europe, 1999).

Meanwhile, in Latin America there is no definition or legislation regarding functional foods. In Uruguay functional foods could be included within 'modified foods' which are defined as those which are specifically prepared to attend the special needs of certain type of consumers and differed from conventional foods due to the fact that their content of one or more nutrients have been modified (MSP, 1994).

Therefore, an internationally acknowledged definition of functional foods is still lacking (Krystallis *et al.*, 2008). Several definitions have been used but there is consensus on the fact that functional foods can be regarded as foods that beneficially affect one or more target functions in the body beyond adequate nutritional effects, in a way that is relevant to either an improved state of health and well-being or a reduction of risk of disease (Margaret *et al.*, 2002).

Persuading people to make healthier food choices and to consume functional foods could provide important public health effects, such as decreased mortality and increased quality of life (Siró *et al.*, 2008). Thus, the development and marketing of functional foods has economic and public interests (Jones & Jew, 2007). At the same time, consumer awareness about the relationship between diet and health has increased, as well as their interest in foods that positively contribute to their health status (Mollet & Rowland, 2002). In this context, functional foods have become an attractive commercial opportunity for food companies.

The lack of an official and unique international definition of functional foods is a constraint for the analysis and monitoring of functional foods markets (Menrad, 2003), as well as for their growth (Castellini *et al.*, 2002). However, considering functional foods as those foods in which ingredients with health-value are added, the global market of functional foods was estimated in 33 billion dollars in 2000 (Menrad, 2003). Sloan (2000; 2002) estimated the global functional foods market in 47.6 billion dollars; being the United States the largest market segment, followed by Europe and Japan. Other authors estimated an even larger global market value for this food category (nearly 61 billion dollars) (Benkouider, 2004). The growth rate of functional foods market for the next 5 to 10 years is estimated in 8 to 10% per annum, which outperforms the overall foods and beverage market's annual growth of about 2% (Castellini *et al.*, 2002; Challener, 2000; Weststrate *et al.*, 2002).

Thus, the opportunities of expansion on the market seem to be quite favourable and the interest of consumers is rather high (Castellini *et al.*, 2002). In this context, functional foods offer the opportunity of launching to the market differential products with added value and interesting growth opportunities.

2. FUNCTIONAL FOODS DEVELOPMENT

The development of functional foods has been one of the most intensive areas of food product development worldwide for the last ten years (Biström & Nordström, 2002). It has specific characteristics that differentiate it from the development of conventional food products (Fogliano & Vitaglione, 2005; Urala, 2005). Functional foods development requires input from food technology, food chemistry, biochemistry, nutrition, medicine, sensory and consumer science, marketing and legislation (Fogliano & Vitaglione, 2005; Jones & Jew, 2007). All these fields must be optimally combined to obtain appealing innovative products for consumers, which maintain the quality standards of conventional products and, at the same time, provide health benefits (Fogliano & Vitaglione, 2005).

The development of functional foods involves different research efforts, including the identification of functional ingredients and the assessment of their physiological effects; the development of a appropriate food matrix in which the functional ingredients could be incorporated; the evaluation of bio-availability and potential modifications during processing, storage and preparation; the study of consumer perception of these products; the effective communication and education of the health benefits to the consumer; and clinical tests to probe product efficacy in order to gain approval for health claims (Kotilainen *et al.*, 2006).

The largest difference between the development of conventional and functional foods is the need for scientific evidence about their positive influence on health (Fogliano & Vitaglione, 2005).

Scientifically proving a health effect needs careful and expensive long-term studies (Urala, 2005; Jones & Jew, 2007), leading the development of such foods a complex, risky, expensive and challenging field for the food industry (Urala, 2005). According to Siró *et al.* (2008) the total cost of developing a regular new food product is estimated in 1 to 2 million dollars; whereas the marketing and development costs of new functional food products are much higher. For these reasons, it is extremely important to speed up functional foods development and to assure the success of the developed products from the early stages of product development.

Functional foods development process is represented in Figure 1. The first stage in functional food development is the creation of an idea or concept of a novel functional food, generally based on knowledge about the relationship between specific compounds and health (Jones & Jew, 2007). Concepts could also be generated by identifying consumers' interest in foods with a particular effect on their health (van Kleef *et al.*, 2002).

After a concept is generated, the next step is its evaluation; which has to be done taking into account consumers' needs. Considering the costs involved in the development of functional foods it is crucial to identify products with a high probability of success. According to Biström & Nordström (2002), marketing and consumer science should be involved since the early stages of the development process in order to avoid time delays and loss of focus.

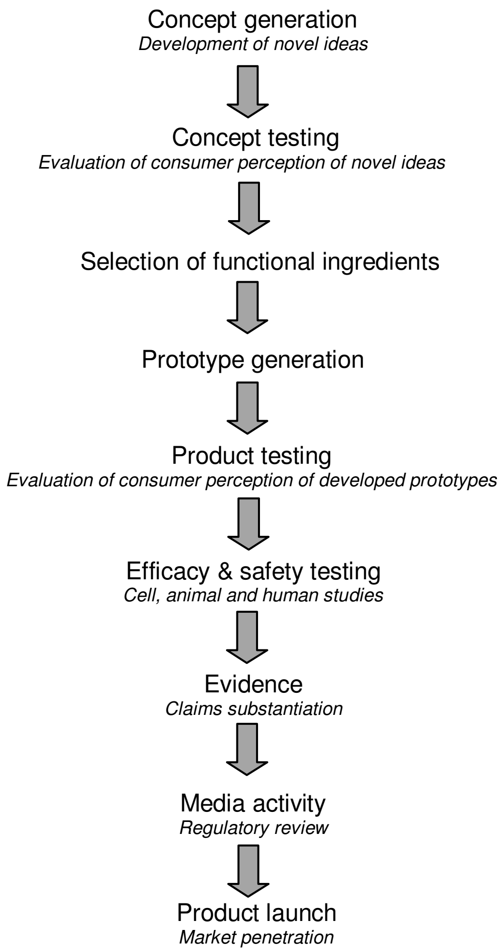


Figure 1. Representation of the stages of functional food products development process.

Once a concept appealing for consumers has been identified, a real product prototype that embraces the concept should be developed (Jones & Jew, 2007).

Often, rendering a concept into a marketable acceptable product is the greatest challenge since many functional ingredients have bitter, acrid, astringent or salty off-flavours (Verbeke, 2006). There are three main strategies to developing functional foods: modifying the raw material (e.g. adding omega-3-fatty acids to hens' diet to achieve omega-3-enriched eggs); modyfing the technological process (e.g. using extrusion or fermentation); and modifying the formulation (e.g. adding fibre) (Fogliano & Vitaglione, 2005). However, regardless of which of these strategies is chosen, one of the key issues in functional food development is how to add the amount of the functional ingredient necessary to achieve a health-benefit from food intake, without negatively affecting the product's sensory characteristics (Fogliano & Vitaglione, 2005). This could generate several formulation and process difficulties that should be resolved. Functional foods which achieve the addition of functional ingredients with the lowest taste alteration, mouth-feel, stability or intestinal side-effects will hold the greatest possibility of becoming successful products (Jones & Jew, 2007). Therefore, an important step in functional foods development is the selection of functional ingredients, and the study of their effects on the characteristics of the base product that act as carrier.

Considering that functional ingredients could have a negative impact on sensory characteristics, product testing becomes an essential step. Once the prototypes are generated, consumer research is necessary in order to assure that consumers will accept the new product when launched into the market (van Kleef *et al.*, 2005).

After the functional food concept has been converted into a product with a good consumer acceptance, the claimed positive effect on health should be investigated (Fogliano & Vitaglione, 2005). Although it is possible to assume that the health effect of the functional product can be supported by previous studies about the relationship between the functional ingredient and health, it is often required to test the product's efficacy and safety (Jones & Jew, 2007). This is mainly due to the fact that the efficacy of many bioactive compounds is affected by the food matrix in which they are incorporated (Jones & Jew, 2007). Efficacy assessment is an essential element to establish the credibility of functional foods, to provide truthful information to support consumer confidence, to satisfy regulatory requirements and to allow fair market competition (ILSI Europe, 1999). In order to provide an adequate scientific validation of the efficacy of functional foods statistically validated data from model systems, retrospective studies, prospective epidemiological studies, and intervention studies on humans should be gathered (Menrad, 2003). However, there is still no scientific consensus on how claims should be evaluated (Agget *et al.*, 2005). Demonstration of clinical efficacy of a functional food is the most critical point of its development process.

Once there is enough scientific evidence to support health claims, the next question is how to communicate the specific advantages of functional foods to consumers. Communication of health benefits to the public has been claimed to be an essential element for improving public health and for the development of functional foods (Agget *et al.*, 2005). Unlike other product characteristics, consumers cannot directly perceive the health benefits derived from functional foods consumption (Urala & Lähteenmäki, 2004; Peng *et al.*, 2006). Therefore, effective communication of the health benefits of a functional food product is necessary to attract consumers' attention. The use of claims is the most common way of communicating the health benefits of functional foods (Jones & Jew, 2007). The claims can be made either directly, as a statement on the label or package of food products, or indirectly, through media campaigns or secondary supporting information (Agget *et al.*, 2005). However, regardless of how these health benefits are communicated to consumers, they should be based on scientific evidence and taking into account legislative aspects (Jones & Jew, 2007; Siró *et al.*, 2008). Regulatory systems vary widely according to the country and some legislation may restrict the use of health claims, which results in an important challenge for communicating the relationship between food and health to the layman consumer (ILSI Europe, 1999; Jones & Jew, 2007). Communication should also avoid problems associated with consumer confusion about health messages (ILSI Europe, 1999; Jones & Jew, 2007).

After a functional food is developed and its beneficial effect on health is proven, consumer acceptance becomes essential in defining market performance (Jones & Jew, 2007). An effective scientific research during functional food development does not make a product successful in the market (Siró *et al.*, 2008). Functional foods are not designed to just satisfy hunger, provide necessary nutrients or generate pleasure but also to prevent diseases and provide well-being to consumers (Menrad, 2003). Therefore, consumers need to be informed and interested in the health effects of functional foods in order to choose consuming them over their conventional counterparts.

Many functional food products developed from scientific opportunities failed when launched to the market (Hilliam, 1998; Wennström, 2000; van Kleef *et al.*, 2005). Moreover, the rate of failure of functional foods is still very high (Fogliano & Vitaglione, 2005). Heasman & Mellentin (2001) attributed this failure to the fact that food companies have not realized that marketing of functional foods differs from conventional ones. Although consumers might be interested in consuming healthy products, the development of persuasive health claims and successful marketing of functional foods has proven to be quite difficult (van Kleef *et al.*, 2005). Failure of functional foods has been related to the fact that consumers' perception had been neglected or at least not appropriately understood (Verbeke, 2005). For this reason, towards the end of the 90's, consumer acceptance was both referred to as the key success factor for functional foods, and the top priority for further research (Childs & Poryzees, 1998). Consumer acceptance of functional foods concept and a better understanding of its determinants have been extensively recognized as the key responsibles for market orientation, consumer-led product development and successfully negotiating market opportunities (Siró *et al.*, 2008).

3. CONSUMERS' ATTITUDES TOWARDS FUNCTIONAL FOODS

The success of functional foods depends on consumers' acceptance of these products as part of their daily diet (Lähteenmäki *et al.*, 2007). Therefore, one key aspect to support the development of functional foods is to better understand consumers' perception of this type of food product (van Kleef *et al.*, 2002; Urala, 2005). By identifying the determinants of consumers' acceptance of functional foods, new food products could be tailored to better appeal to potential buyers and assure their success in the marketplace.

Consumers do not perceive functional foods as specific products, different from their conventional counterparts (Urala & Lähteenmäki, 2003). Actually, consumers perceive them as member of the particular food category to which they belong (Urala & Lähteenmäki, 2003; Siró *et al.*, 2008). When shopping for a product within a certain food category, consumers have to choose between functional and conventional foods. Thus, consumers can only be expected to choose functional foods over conventional ones if the former are perceived as healthier. Consumers need to be informed about their beneficial health effect, they must trust in the health claim, perceive it as safe and they must have a perceived need for using the product (Lähteenmäki, 2003).

However, consumers' attitudes towards functional foods do not depend only on their perceived healthiness, but also on the same characteristics, including sensory quality, price and convenience, as any conventional product. This is due to the fact that consumers are not willing to negotiate those characteristics for eventual long-term health benefits (Lähteenmaki, 2003; Urala & Lähteenmäki, 2003; Verbeke, 2006; Siró *et al.*, 2008). The health benefit of a functional food only gives additional value to the product (Urala & Lähteenmäki, 2007; Siegrist *et al.*, 2008; Siró *et al.*, 2008).

As in any food product, consumers' acceptance of functional foods depends on the carrier product, the consumer, and the health claim attached to it (Lähteenmäki, 2003).

Several authors have studied demographic, cognitive, motivational and attitudinal determinants of consumer acceptance of functional foods (Bech-Larsen & Grunert, 2003; Cox *et al.*, 2004; Saher *et al.*, 2004; Urala & Lähteenmäki, 2004; Verbeke, 2005; Verbeke, 2006; Labrecque *et al.*, 2006; Herath *et al.*, 2008; Krystallis *et al.*, 2008; Siegrist *et al.*, 2008; Siró *et al.*, 2008).

Demographic variables have been reported to have a great influence on consumer acceptance of functional foods. Typical functional foods consumers have been identified as female, well educated, higher socioeconomic class and older than 55 years (Hilliam, 1996; Childs & Porzees, 1997; Poulsen, 1999; Bogue & Ryan, 2000; Anttolainen *et al.*, 2001; de Jong *et al.*, 2003; Niva *et al.*, 2003; Verbeke, 2005; Verbeke, 2006; Labrecque *et al.*, 2006; Herath *et al.*, 2008; Krystallis *et al.*, 2008; Siegrist *et al.*, 2008).

Females have been reported to be more familiar with functional foods, and to more frequently consume these food products than men (Childs & Porzees, 1997; Bogue & Ryan, 2000; Herath *et al.,* 2008 Verbeke, 2005; Verbeke, 2006; Labrecque *et al.*, 2006; Siró *et al.*, 2008). This has been related to the fact that women are usually more interested in health-related issues (Roininen *et al.*, 1999; Beardsworth *et al.*, 2002). The higher interest of females towards functional foods has important implications considering that they are frequently the person responsible for food selection and shopping in the household (Bech-Larsen & Scholderer, 2007).

Middle-aged and elderly people are usually more aware of health issues because they are more likely to be diagnosed with a lifestyle-related disease than younger consumers (Verbeke, 2006), which may explain a higher functional foods intention to purchase (Poulsen, 1999; Herath *et al.*, 2008). Moreover, older consumers seem to show different attitudes towards health claims and type of functionality than younger ones, preferring health claims that emphasize the prevention of diseases (Bhaskaran & Hardley, 2002; van Kleef *et al.*, 2005).

The influence of socio-demographic variables could not be analyzed without taking into account the type of functional food and its health claim, since there are clear differences in the influence of sociodemographic variables between different functional food products (Poulsen, 1999; de Jong *et al.*, 2003: Stewart-Knox *et al.*, 2007).

Several issues play a role on the acceptance and willingness to use functional foods, and personal motivation is among them. Consumers must be interested in achieving or preserving a good health status, and they must regard functional foods as important in helping them staying healthy (Urala, 2005; Krystallis *et al.*, 2008).

Perceived reward was reported to be the strongest single predictor for willingness to use functional foods by Urala & Lähteenmäki (2007); whereas Cox *et al.* (2004) found that self-efficacy was the best predictor of the intention to consume a functional food with a stated memory improvement claim. Furthermore, Herath *et al.* (2008) stated that a key driver of functional foods acceptance is perceived disease threat. According to several authors, the interest in functional foods is affected by the health condition of the consumers and their family (van Kleef *et al.*, 2005; Verbeke, 2005). Personal experiences with illness and the existence of a family member with a specific health problem increase the probability of accepting functional foods (Wrick, 1995; Verbeke, 2005). However, consumers' interest in health issues is not enough to support the consumption of functional foods (Krystallis *et al.*, 2008).

Trustiness also plays an important role since consumers do not directly and immediately experience the health benefits of these products (Siegrist *et al.,* 2008; Verbeke, 2005). Consumers who trust in the food industry seem to be keener on buying functional foods than those who do not trust in it. Niva *et al.* (2003) reported that trust was determinant on the frequency of use of cholesterol-lowering spread.

According to Labrecque *et al.* (2006) high knowledge on the health benefits of functional foods is also relevant on the acceptance of these products, together with health and product-related benefits, beliefs and credibility of information. Nutritional knowledge has been claimed to have a great influence on dietary behaviour (Patterson *et al.*, 1995; Harnack *et al.*, 1997; Wardle *et al.*, 2000). Several studies have reported that increasing nutritional knowledge is associated to higher intake of fruits and vegetables (Wardle *et al.*, 2000; Patterson *et al.*, 1995). However, according to several authors the influence of nutrition knowledge on food preferences and selection is rather small (Shepherd, 1992; Wardle *et al.*, 2000; Räsänen *et al.*, 2003). Crites & Aikman (2005) suggested that increasing nutrition knowledge makes health a more important determinant of attitudes but that overall attitudes and behavior change less due to the fact that other evaluative bases are not affected by nutrition knowledge. Wansink *et al.* (2005) reported that consumers who had both attribute-related knowledge and consequence-related knowledge of functional foods were more willing to consume these products than those who had only one type of information. Thus, in order to accept functional foods, consumers should know that the food contains a certain functional ingredient and which are the consequences related to the consumption of that particular functional ingredient. Due the limited consumers' knowledge of the health effects of functional ingredients, there is a strong need for information and communication activities to consumers (Menrad, 2003).

Functional food consumers might be those who are interested in taking care of their health status, who receive, understand and trust the 'message' of functional foods and who feel in control of their health condition (Schmidt, 2000).

The perceived healthiness of the base product has a great influence on consumers' perception of functional foods. Carrier products with a healthy image have been reported to be more attractive than carriers with an unhealthy image (Balasubramanian & Cole, 2002; van Kleef *et al.*, 2005; Siegrist *et al.*, 2008). Consumers' attitudes towards functional foods are more positive when intrinsically healthy products, such as yogurt, cereals, bread, and juice are considered (Siró *et al.*, 2008). However, the opposite trend was reported by Bech-Larsen & Grunert (2003). These authors stated that consumers considered the enrichment of 'non healthy' foods more justified than enrichment of foods which are perceived as healthy per se.

Consumers' perception of the functional ingredient is also important in determining functional foods acceptance. Familiar functional ingredients (e.g. vitamins, fiber, minerals) are usually preferred to novel functional ingredients (e.g. polyphenols, selenium, flavonoids) due to the fact that consumers are not aware of the health benefits of the latter group of ingredients (Bech-Larsen & Grunert, 2003; Bech-Larsen & Scholderer, 2007; Siró *et al.*, 2008). Regarding the health effect of the functional ingredient, van Kleef *et al.* (2005) and Siegrist *et al.* (2008) reported that consumers rated physiological health claims as more attractive than psychological health claims; whereas van Trijp & van der Lans (2007) reported that yogurts with the added benefits of reducing the negative impact of stress or improving concentration had lower consumer appeal than products strengthening the body's natural defense system. However, consumers do not perceive functional ingredients independently from the carrier product (van Trijp & van der Lans, 2007; Siegrist *et al.*, 2008). Poulsen (1999) stated that consumers prefer functional ingredients that are already contained in the base product. Therefore, consumers' prior thoughts about the healthiness of the base product and the functional ingredient are key determinants of their attitudes towards functional foods and sometimes might override the influence of health claims (Siró *et al.*, 2008).

Food companies usually use health claims to efficiently communicate the health-effect of functional foods to consumers. The extent to which consumers find health claims appealing and trusty depends on the content and format of the message (Mazis & Raymond, 1997). There are basically two types of health claims: ‘enhanced function’ and ‘reduced disease risk’ (ILSI Europe, 1999). ‘Enhanced function’ claims relate to the consumption of a food or food component that contributes beneficially to health. ‘Reduced disease risk’ claims relate to the consumption of a food or food component that helps to reduce the risk of a specific disease or an undesirable health condition. Therefore, message of health effects could be formulated to provide a potential benefit (e.g. ‘enhanced function’) or to prevent a negative situation (e.g. ‘reduced disease risk’). The use of one type of claim depends on which has the greater persuasive impact on consumers (van Kleef *et al*., 2005). According to Krishnamurthy *et al.* (2001) and Levin *et al.* (1998), in the context of attribute framing, people react more positively to positive than negative messages. Therefore, it has been stated that health claims that emphasize the positive influence of functional foods are preferred over health claims that emphasize the prevention of diseases (Krishnamurthy *et al*., 2001; Levin *et al.,* 1998; Aaker & Lee, 2001; Menrad, 2003). In this context, enhanced function claims might be more appealing to consumers than reduced disease risk claims, because the former evoke positive associations from memory (van Kleef *et al*., 2005). ‘Reduced disease risk’ might confront consumers with illness and problems they might suffer in the future. However, little research has been made on this topic and results in literature regarding the effect of claims are rather contradictory. While van Kleef *et al.* (2005) reported that Dutch consumers reacted more favorably to 'disease reduced risk' claims than to 'enhanced function' framed health claims; Bech-Larsen & Grunert (2003) reported the opposite trend. van Kleef *et al.* (2005) have reported that consumers preferred health claims that stress the prevention of physiologically based illnesses. This could be explained considering that in many cases negative information is more informative, attracts more attention and stimulates deeper processing than positive information (Levin *et al.*, 1998).

Sensory characteristics have been identified as one of the main determinants of food choice (Steptoe *et al.*, 1995; Rozin, 1996; Lindeman & Väänänen, 2000; Prescott *et al.*, 2002; Eertmans *et al.*, 2006). Negative changes in the sensory characteristics of foods due to the addition of functional ingredients might cause potential aversive consumer reactions (Siró *et al.*, 2008). Despite the fact that some authors suggested that off-flavours could be considered as a marker of the health benefit of functional foods (Juttelstad,1998); others have reported that consumers are hardly willing to consume functional foods they do not like (Gilbert, 2000; Tuorila & Cardelo, 2002; Cardello & Schutz, 2003; Cox *et al.*; 2004; Verbeke, 2006; Ares *et al.*, 2009a). Gilbert (2000) studied consumers' interest in healthy foods and found that the primary obstacle to make healthy choices is taste. According to Bower *et al.* (2003), in addition to health claim, purchase intent of functional spreads was strongly related to consumers' liking. Moreover, Huotilainen *et al.* (2006) reported that liking ratings of new functional drinks were the best predictors for frequency of use.

These findings suggest that consumers expect functional foods to have good sensory properties that provide them hedonic pleasure, apart from having a positive influence on their health (Urala, 2005). Thus, development of functional foods with bad sensory characteristics is a risky option since consumers might not be willing to repeatedly consume them (Hilliam, 2003; Verbeke, 2006).

Another relevant issue in functional foods acceptance is price. Functional foods might be more expensive than their conventional counterparts and might affect consumers' acceptance. According to several authors there is a group of consumers who are not affected by a price increase, and are willing to pay premium price for functional foods (Poulsen, 1999; Bogue & Ryan, 2000; Bech-Larsen, 2001). However, consumers seem to be only willing to accept limited price increase for functional foods (Menrad, 2003), such as 30 to 50% when compared to their conventional counterparts, as estimated by Kotilainen *et al.* (2006).

In summary, consumer acceptance of functional foods is far from being unconditional; being sensory characteristics, price, interest and trustworthiness of health claims the main determinants of acceptance. Functional foods might be tailored for certain purposes and groups of consumers, instead of being mass food products (Lähteenmäki, 2003). In this context, consumer research during the development of this type of product becomes essential.

4. CONSUMER-DRIVEN NEW FOOD PRODUCT DEVELOPMENT

Despite the fact that new food product innovation and development is necessary for food companies to survive in today's highly competitive market, the vast majority of new food products fail (Stewart-Knox & Mitchell, 2003). Rate of failure of new food products has been estimated in 72 to 90% (Buisson, 1995; Rudolph, 1995; Lord, 1999; Stewart-Knox & Mitchell, 2003). Moreover, it is estimated that only 7 to 25% of the food products launched to the market are really novel (Rudolph, 1995; Lord, 1999). The low innovation and high failure rate of new food products suggests that the methodology used for new food product development is seriously flawed and needs improvement (Rudolph, 1995; Stewart-Knox & Mitchell, 2003).

The food product development process is complex, iterative and consequently difficult to define and model (Rudolph, 1995). Several authors have analyzed it, in order to identify the key factors responsible for product success (Calatone & Cooper, 1979; Cooper & Kleinschmidt, 1987; Rudolph, 1995; Cooper, 1988; Hoban, 1998; Kristensen *et al.*, 1998; Dahan & Hauser, 2001; Rudder *et al.*, 2001; Stewart-Knox & Mitchell, 2003). Calatone & Cooper (1979) stated that product success is dependent upon the product uniqueness and superiority; good understanding of consumer wants, needs and preferences; good communication between product development team; management support; and effective product marketing and launch. Similar view has been reported by several authors (Cooper & Kleinschmidt, 1987;

Cooper, 1988; Hoban, 1998; Kristensen *et al.*, 1998; Stewart-Knox & Mitchell, 2003). According to Dahan & Hauser (2001) and Rudder *et al.* (2001) product success is related to consumer testing and effective communication of consumer needs to the technical development team.

It is imperative to food companies to include consumers in the early stages of the development process because a consumer-driven food product development process is likely to yield more successful products (Von Hippel, 1977; 1978; Urban & Hauser, 1993; Moskowitz, 1994a; Moskowitz, 1994b; Lord, 1999; Costa *et al.*, 2001; Stewart-Knox & Mitchell, 2003).

The product development process has three main phases: product definition, product implementation and product introduction (Rudolph, 1995).

The first stage of the product definition phase involves the search for new ideas, which typically requires the identification of consumers' unmet needs and wants (van Kleef *et al.*, 2005). Despite the importance of the later phases, it is increasingly recognized that successful new product development depends on the quality of the product definition phase (Cooper, 1988; 1993; 1998; McGuinness & Conway, 1989; Stewart-Knox & Mitchell, 2003; van Kleef *et al.*, 2005). It is extremely important to understand how consumers perceive food products, how their needs and wants are shaped and how they make their everyday food choices based on those needs and wants (van Kleef *et al.*, 2005). Moreover, carrying out consumer research in this stage of new food product development is not expensive compared to the risk of product failure. Consumer research in this phase is considered difficult because consumers are usually not able to say what they want. However, there are several methodologies that could be used at this stage to gather information about consumers' needs (Ulwick, 2002; van Kleef *et al.*, 2005).

After consumers' unmet wants and needs are identified, the next step is to determine how those wants and needs will be addressed by the product that will be developed. This involves defining the characteristics of the product and requires the integration of consumers' perception, business objectives, product delivery requirements, and regulatory issues (Rudolph, 1995). After this stage, a series of new product ideas are generated, which should be subjected to a screening step.

The objective of the screening step is to select a series of new product ideas for further investigation and development from those generated in the previous stage (Cooper, 1988). Screening includes assessing consumers' reaction to the new developed product concept and identifying important attributes. Although this is usually not a consistent and well-established step in new food product development process, it should be considered as a formal step in order to prevent working on new products that have low probability of success (Cooper, 1988; Rochford, 1991).

There are several methodologies that could be used during the product definition stage, for both idea generation and screening. However, most food companies do not use these methodologies or use them in an inappropriate way (Wind & Mahajan, 1997; Nijssen & Frambach, 2000). Large part of the consumer research conducted in this phase of new product development consist on focus group, surveys and the study of socio-demographic data (van Kleef *et al.*, 2005). These methodologies usually fail to reach their full potential in food product development and provide limited and confusing information (van Kleef *et al.*, 2005). Furthermore, the fact that most food companies only use these methodologies has been considered one of the reasons of the relatively low success rate of new food products (Wind & Mahajan, 1997).

Some of the methodologies that could be used for understanding consumers' wants and needs in the first stages of new product development are: emphatic design, category appraisal, conjoint analysis, focus group, word association, free elicitation, information acceleration, lead user technique, Kelly's repertory grid, laddering, and Zaltman metaphor elicitation.

The abovementioned methodologies are used according to the purpose of the project, being implemented the empathic design, information acceleration, lead user technique, and Zaltman metaphor elicitation technique when radically new products (those that do not fall into an existing category) are considered (van Kleef *et al.*, 2005). On the other hand, focus group, free elicitation, word association, Kelly repertory grid, laddering, category appraisal and conjoint analysis are particularly useful when incremental new products are considered, i.e. modified versions of existing products. Therefore, considering that consumers perceive functional foods as products within a certain category, these methodologies would be the most appropriate for consumer-driven functional food development.

All the methods used for developing incremental new products are mainly based on consumers' perception of the products available in the market, due to the fact that product stimuli are presented during the task. Thus, they provide information about consumers' needs and wants related to the particular product under study; which allows the optimization of products within existing categories. Their main limitation is the fact that it could be difficult to elicit consumers' unfulfilled needs because consumers usually only focus on and think of the products available in the market (van Kleef *et al.*, 2005).

Conjoint analysis, Kelly's repertory grid and category appraisal are considered highly actionable methodologies since they provide precise information about the influence of sensory and non-sensory product characteristics on consumers' acceptance.

Conjoint analysis is a useful tool to quantify the effect of different attributes on consumers' perception of a food product. This technique has been widely used in market research to study the influence of controlled stimuli on consumer response (Green & Rao, 1971; Green & Wind, 1975; Green & Srinivasan, 1980; 1990; Moskowitz & Silcher, 2006). It consists on a set of procedures that attempt to investigate consumers' responses to combinations of product attributes, aiming at understanding the contributions of each of these attributes to consumers' acceptance of a certain food product (Moskowitz & Silcher, 2006). Conjoint analysis estimates the relative importance of a series of product's attributes by decomposing consumers' judgment about a set of complex alternatives into separated and compatible utilities by which the original global judgment can be reconstituted (Cattin & Wittink, 1982). Conjoint analysis assumes that a product could be defined as a group of attributes from which consumers gain utility and that consumers maximize their preferences when deciding their food choices (Carson *et al.*, 1994; Hensher, 1994; Jaeger *et al.*, 2001). In rating-based conjoint analysis consumers are asked to use scales to rate a set of stimuli that are systematically varied combinations of attributes. Respondents' ratings are assumed to represent the perceived magnitude of the stimulus on the particular attribute being rated (Moskowitz & Silcher, 2006). The use of experimental design techniques and analysis of variance enables the estimation of the relative importance of each attribute on consumers' perception of the product under study (Deliza *et al.*, 2003). Conjoint analysis has been used for several applications such as product and package development, market segmentation and for studying the influence of brand and information on consumers' perception of food products (Carneiro *et al.*, 2005; Moskowitz & Silcher, 2006).

Kelly's repertory grid consists on a personal interviewing technique that allows understanding which product characteristics are relevant for consumers (Gains, 1994). Products are arranged into triads (groups of three), and presented to participants in such way that two of the objects within the triad are arbitrary grouped and separated from the third (Gains, 1994). Consumers are asked to describe how the two grouped objects are similar and different from the third, and then asked to quantify the products for each of the elicited attributes (Kelly, 1955). According to Steenkamp & van Trijp (1997) this technique yields fewer attributes than other less structured techniques, such as free elicitation.

Category appraisal consists of a set of techniques that provide information on consumers' perception of products available in the market within a certain category (van Kleef *et al.*, 2005). Thus, it enables the identification of product opportunities and key drivers of liking.

Focus group is a group discussion technique conducted by a qualified moderator with 8-12 people, and designed to gather information about consumers' perception of a specific subject in a permissive and non-threatening environment (Casey & Krueger, 1994; Krueger, 1994). Analysis of participants' views and opinions could provide information about the key drivers of consumer choice for a particular product category, or relevant issues about consumers' perception of new product concepts (van Kleef *et al.*, 2005). One of the advantages of focus group interviews is that it encourages and captures interaction between participants; which provides the chance of studying the influence of people on consumers' perception of a specific product (Casey & Krueger, 1994). Some of the limitations of this technique include the need for a trained and experienced moderator; the cost and time required for performing the sessions and the difficulty of analyzing the elicited information (Casey & Krueger, 1994).

Free elicitation is a personal interviewing technique in which respondents are asked to express the attributes they consider important for a particular product (van Kleef *et al.*, 2005). The basis of this technique is the memory schemata concept (Collins & Loftus, 1975) that states that people acquire knowledge structures during their life course which determine their perception of a certain stimulus. Thus, this methodology provides information about concrete product characteristics that are relevant for consumers' perception (van Kleef *et al.*, 2005).

Laddering is a widely used methodology in marketing research (Reynolds & Gutman, 1988). It tries to identify the underlying relationships between product attributes and consumers' personal values that motivate their decisions by facing consumers with a familiar product stimulus. There are two modalities for this methodology, one that consists on a personal interview by a highly trained interviewer, and the other that relies upon a self-administered structured questionnaire (Botschen & Thelen, 1998; Russell *et al.*, 2004a). This methodology usually provides information about consumers' motivations for purchasing a certain food product; being more useful for evaluating consumers' interest in a concept than for providing specific directions about product characteristics for food product development.

Word association is a qualitative methodology, recently applied within sensory and consumer science (Roininen *et al.*, 2006). It consists of asking participants to provide the first associations that come to their minds when thinking of a certain product concept. The elicited terms might be the most relevant regarding consumers' perception of the product (Ajzen & Fishbein, 1980). The main advantage of this technique is that consumers' responses are not influenced by interviewers or other participants' opinions, as in focus groups.

Therefore, there is a wide range of methodologies available for studying consumers' perception in the first stages of new food product development process, which could yield interesting and highly valuable information to support successful products.

Once the characteristics of the product that will be developed have been fully defined, product implementation phase starts (Rudolph, 1995). It aims at translating consumers' needs and expectations into specific formulation and process characteristics of a food product (Juran & Gryna, 1993). This phase requires three basic steps: (i) identification of critical product attributes important to consumer acceptance, (ii) development and screening of different prototypes, which includes the determination of key ingredients, and (iii) an optimization step for selecting the concentration of the most important ingredients (Lagrange & Norback, 1987; Schutz, 1983). In all these steps, investigating consumers' perception of the products is critical.

In product implementation, product formulation and processing conditions are systematically varied following an experimental design which enables to evaluate how these variables affect the products' sensory characteristics and consumers' perception (Moskowitz, 1994b). Experimental design is widely regarded as one of the most significant and useful tools for new product development (Blake *et al.*, 1994). There are several experimental designs that could be used during prototype development and product optimization (Gacula, 1993). The selection of a certain experimental design depends on the stage of the product implementation phase (Gacula, 1993).

During prototype development and screening it is important to identify which formulation or processing variables are important for consumers' acceptance (Rudolph, 1995). In this step, a large number of variables are considered to develop different prototypes and the most important ones are identified. Some of the most used experimental designs are incomplete fractional factorial designs (Gacula, 1993). Taguchi experimental designs could also be extremely useful at this stage. Although the method was developed for producing robust products and manufacturing process at low cost, it also provides appropriate experimental designs for screening purposes (Gacula, 1993). Taguchi's orthogonal arrays are experimental designs, similar to fractional factorial designs, which yield quite a large amount of information about the main effects in a relatively few runs, saving both time and money (Kacker *et al.*, 1990; 1991). The identification of which formulation variables are important for consumers could also be done considering the products available in the market, by performing a category appraisal task (Moskowitz, 1994a).

After manufacturing a series of prototypes following a certain experimental design, they should be evaluated by consumers. The main objective of prototype testing is to detect and correct potential products before proceeding further in new product development process (Ozer, 1999). In this stage companies can gather information that enables to: (i) evaluate if consumers' like the developed prototypes and if they are willing to buy them, (ii) evaluate if the prototypes satisfy consumers' expectations, (iii) compare the products with others available in the market, (iv) identify potential problems of the prototypes and determine how they could be improved, and (v) study how consumers preferences change after using the product (Ozer, 1999).

The objective of most quantitative research conducted in this phase of product development is to determine consumers' affective reaction to different products by asking consumers to rate how much they like a product, i.e. to score their overall liking using a hedonic scale (Popper *et al.*, 2004). The 9-point hedonic scale developed by Peryam & Pilgrim (1957) is the most widely used for this purpose.

Preference mapping is extensively used in this stage of food product development process. Preference mapping consists on a group of techniques that enables to investigate the relationship between sensory characteristics of food products and consumers' liking, in order to understand what characteristics drive consumer preferences (Schlich, 1995; McEwan, 1996; Arditti, 1997). These methodologies are useful for several purposes, including marketing, product development, improvement and optimization of existing products (Greenhoff & MacFie, 1994; van Kleef *et al.*, 2006). There are two approaches to preference mapping: internal and external (van Kleef *et al.*, 2006).

Internal preference mapping consists on creating a product map based on consumers' preferences by performing a principal component analysis on overall liking scores (Greenhoff & MacFie, 1994). The purpose of this methodology is basically to determine the key sensory attributes responsible for consumers' liking and to visualize groups of consumers with different preference patterns (van Kleef *et al.*, 2006).

External preference mapping techniques refer to a series of approaches to relate consumers' overall scores to a configuration of products determined by their sensory or physico-chemical characteristics, i.e. the products' configuration in a sensory or physico-chemical space (Carrol, 1972; Meullenet *et al.*, 2008b). Individual consumer scores are fitted into the product configuration in the sensory (or physico-chemical) space using a regression model (Danzart, 1998). After this, individual models are overlapped to create a density plot of consumer acceptance and the points of maximum density are considered the ideal products (Danzart *et al.,* 2004).

After the most important variables formulation and processing variables have been identified, an optimization step is performed to maximize consumer acceptance of a food product (Lagrange & Norback, 1987).

Product optimization could be carried out using response surface methodology. It consists of a series of experimental strategies, mathematical methods, and statistical inference which enables to identify optimum areas within a certain experimental region (Box & Wilson, 1951). In experimental food product formulations with multicomponent mixtures, response surface can reveal the best formulations, i.e. those that will maximize consumers' liking (Gacula, 1993). Using response surface, a set of combination of formulation or processing variables is created following an experimental design, yielding a range of different product alternatives. Then, the mean consumers' overall liking is modeled using a second-degree polynomial model and optimum combinations of formulation or processing variables are identified, which may generate a highly acceptable product (Box & Wilson, 1951; Moskowitz *et al.*, 2005).

Apart from response surface modeling, external preference mapping techniques could be used to identify consumers' optimum product. The advantage of this methodology is that it takes into account consumers' individual liking data instead of average data; providing a more accurate representation of the marketplace.

Finally, once the product has been developed, packaged and priced to convey the correct messages of quality and value, it is launched into the market (Rudolph, 1995). This phase is called product introduction and is mainly led by sales and supported by marketing and distribution (Rudolph, 1995). Once the product has been launched into the market, consumers' initial response usually reveals its potential for success and, therefore, how effective its development process was.

OBJECTIVES

OBJECTIVES

The general objective of the thesis was to apply and study different sensory and consumer methodologies in the development of a functional food product.

The specific objectives of the present thesis were the following:

- To determine motives underlying Uruguayan consumers' food choices.
- To investigate Uruguayan consumers' perception of functional foods using different methodologies such as word association, laddering and conjoint analysis.
- To study the influence of different variables (carrier product, functional ingredient, name used to declare the addition of the ingredient, information about the source of functional ingredients, type of health claim and nutritional knowledge) on consumer perception of functional foods.
- To identify a Uruguayan a consumer-driven functional food considering functional ingredients and carrier products.
- To evaluate antioxidant extracts from Uruguayan native plants as functional ingredients.
- To develop a chocolate milk dessert enriched with an antioxidant of a Uruguayan native plant.
- To profile the sensory characteristics of chocolate milk desserts using distinct methodologies.
- To investigate the role of expectations on consumers' perception of chocolate milk desserts enriched with antioxidants.

STRUCTURE OF THE THESIS

STRUCTURE OF THE THESIS

The thesis was divided into three main parts: the study of Uruguayan consumers' perception of functional foods (Chapters 1 to 3), the study of antioxidant extracts from Uruguayan native plants as functional ingredients (Chapter 4) and the development of a functional food enriched with antioxidants (Chapters 5 and 6).

The first study was carried out to identify Uruguayan consumers' motives underlying their food choices (Chapter 1). Results have shown that consumers attributed a high relative importance to health in their everyday food choices, suggesting that they could be interested in the consumption of functional foods. Chapter 2 focused on consumers' perception of functional foods using two qualitative methodologies: word association and hard laddering. Results indicated that consumers had a positive attitude towards functional foods, so, the following chapter investigated the influence of different variables (carrier product, functional ingredient, name used to declare the addition of the ingredient, information about the source of functional ingredients, type of health claim and nutritional knowledge) on consumers' perceived healthiness and willingness to try functional foods using conjoint analysis (Chapter 3). Results showed that consumers were interested in dairy desserts enriched with antioxidants. Therefore, the development of this functional food product was carried out.

In Chapter 4 antioxidant extracts from three Uruguayan native plants were evaluated as functional ingredients. Based on their sensory characteristics, polyphenolic content and radical scavenging capacity, water extracts from A*chyrocline satureoides* were selected for the development of a functional food product. Alternatives to reduce the high bitterness, astringency and characteristic flavour of this extract, were studied by adding sucrose, sucralose, polydextrose, milk and flavourings. Results suggested that sweetened chocolate dairy products could be appropriate carriers for the development of functional foods containing polyphenolic-rich antioxidant extracts from *Achyrocline satureoides*. Thus, considering these results and those from Chapter 3, chocolate milk desserts enriched with antoxidants were developed.

In Chapter 5, the formulation of a regular milk dessert that could serve as base product for the development of a functional dessert was selected using different methodologies, such as projective mapping, open-ended and check-all-that-apply questions and external preference mapping.

Finally, in Chapter 6 chocolate milk desserts enriched with a water extract from *Achyrocline satureoides* were developed and consumers' product expectations were studied.

CHAPTER 1

UNDERSTANDING URUGUAYAN CONSUMERS' FOOD CHOICES

ABSTRACT

The aim of the present chapter was to study the food choice behaviour and food frequency consumption of a sample of Uruguayan consumers. A modification of the Food Choice Questionnaire and a food frequency questionnaire were administered to a group of 200 Uruguayan consumers. '*Feeling good and safety'*, '*Sensory appeal'* and '*Health and nutrient content'* were rated as the most important factors in determining consumers' food choices; whereas '*Familiarity'* was rated as the least important. The high relative importance given to health suggests that the development of healthy and functional foods might be appealing for consumers.

The studied consumer sample showed a low consumption frequency of fruits, vegetables and whole cereals, which indicate that the development of functional foods enriched with fibre or antioxidants could be an alternative to improve their nutritional status. Moreover, dairy products and bakery appear to be the most feasible base products for functional foods development as they were the food categories that showed the highest consumption frequency.

Using hierarchical cluster analysis three clusters with different choice patterns were identified. Significant differences in the consumption frequency of fruits, vegetables and fatty foods were also found between the clusters. Frequency consumption of fruits, vegetables, milk and dairy products, and whole cereals increased as the importance attributed to health and nutrition increased; while consumption of fatty foods decreased. This remarks the

importance of health on food choices, stressing the possible interest in the development of functional foods.

1.1. INTRODUCTION

Food choice is a very complex process which involves many different interrelating factors. Many qualitative food choice models have been developed to understand food choice behaviour and to illustrate the factors influencing this process (Yudkin, 1956; Pilgrim, 1957; Khan, 1981; Randall & Sanjur, 1981; Sheperd, 1989). Basically, these models provide a list of factors that are likely to affect consumer food choices (Sheperd & Sparks, 1994).

Randall & Sanjur (1981) sorted the factors influencing food choice in those related to: (a) the individual (gender, age, education, income, nutrition knowledge, cooking skills, attitudes to health), (b) the food (sensory characteristics, method of preparation, seasoning, cost) and (c) the environment (season, employment, mobility, size of household, stage of family, degree of urbanization). Similarly, Shepherd (1989) developed a model which also includes three factors related to food choice behaviour: (a) food: its physical properties and nutrient content, (b) the individual: his/her previous experience and learning associated with foods, which in turn will lead to different beliefs, values and habits, and (c) social-economic environment: attitudes to sensory properties of food or healthiness of food. On the other hand, a more recent model of food choice is the conceptual model developed by Furst *et al.* (1996). It has three main components: (a) life course: person's experiences, (b) influences: ideals, personal factors, resources, social framework and food context, and (c) personal system of strategies for making choices and value negotiations: sensory perceptions, monetary considerations, convenience, health and nutrition, management of relationships and quality.

All the above mentioned models are broadly similar and mainly differ in emphasis (Sheperd & Sparks, 1994). In general, variables influencing food choice could be divided into three main categories: those related to the food, to the person making the choice and to the external economic and social environment within which the choice is made. However, these models do not quantify the importance of the different factors or provide information about how they interact (Sheperd & Sparks, 1994).

Actual empirical evidence on the relative importance of different food choice motives in various populations and situations remains rather scarce (Sheperd & Sparks, 1994; Prescott *et al.*, 2002; Eertmans *et al.*, 2006). Most published studies about food choice have been performed in developed countries in Asia, Europe and USA (Steptoe *et al.*, 1995; Rozin, 1996; Lindeman & Väänänen, 2000; Prescott *et al.*, 2002; Eertmans *et al.*, 2006). In these studies health, sensory appeal, convenience and price have been reported to be the most important factors influencing food choice. However, there is scarce information regarding motives underlying food choice in developing countries, particularly in Latin America (Iop *et al.*, 2009).

The relative importance of the different factors influencing food choice can be determined by using relationships between the beliefs and attitudes held by a person and the food choices he (she) makes (Shepherd & Sparks, 1994). A useful instrument for evaluating motives for food choice is the Food Choice Questionnaire (FCQ), developed by Steptoe *et al.* (1995), which contains 36 items, representing both health and non-health related food attributes (Appendix A). Respondents are asked to rate the importance of each of these items for their food choice 'on a typical day' using a 4-point scale. The FCQ involves nine motivational factors, each comprised of three to six of the 36 items of the questionnaire. These factors are: Health, Mood, Convenience, Sensory Appeal, Natural Content, Price, Weight Control, Familiarity, and Ethical Concern. According to the authors these factors comprise a wide range of variables that are relevant for food choice within western urban populations. The development of this questionnaire was performed considering a UK population sample but has been used in different European and Asian countries, which confirms its validity. The scale has also been shown to differentiate motives underlying food choice between subgroups based on gender, age, income (Steptoe *et al.*, 1995) and vegetarianism (Lindeman & Väänänen, 2000).

Understanding the reasons behind consumers' food choices could provide valuable information for food product development, as it could help to identify what consumers want and need. Knowing what consumers take into account when deciding to buy or to reject a certain food product could lead to the design of food products that successfully address consumers unfulfilled needs and could avoid the development of products that are destined to fail in the market. Moreover, information about what consumers take into account when selecting a food product could be useful in the design of marketing strategies for promoting novel foods. Information has been shown to impact consumers' expectations and preferences (Deliza & MacFie, 1996). Therefore, promoting a certain product considering consumers motives underlying their food choices could be a mean to gain acceptance for the introduction of novel foods (Prescott *et al.*, 2002). Combining knowledge of the appropriate sensory properties in initial product development with an understanding of the types of information that consumers' value may be a powerful approach to food product development (Prescott *et al.*, 2002).

In the case of the development of functional foods, understanding the importance that consumers attribute to health related issues could provide information about their potential interest in this type of products.

Motives underlying food choice are likely to affect consumer's food intake and therefore determine their nutrient intake (Furst *et al.*, 1996). Consumers' dietary patterns might vary according to which factors they consider when selecting their food. Therefore, understanding the motives underlying consumers' food choices could help understanding their dietary patterns and also contribute to the improvement of health by positively influencing food habits (Steptoe *et al.*, 1995). Although extensive nutrition education campaigns have been carried out in many Western countries during the last few decades, there is still a gap between dietary recommendations and quality of diet (Wardle & Steptoe, 1991; Steptoe & Wardle, 1992; Stafleu *et al.*, 1995; Wardle *et al.,* 1997; Rozin *et al.*, 1999). Therefore, understanding consumers reasons for food choice could provide information to achieve an effective modification of dietary patterns (Steptoe *et al.*, 1995).

The aim of the present chapter was to study the factors that influence food choices of a sample of Uruguayan consumers and the relationship between food frequency consumption of selected items and motives for food choice.

1.2. MATERIALS AND METHODS

1.2.1. Subjects

Data was collected through a survey with 200 consumers, who were randomly recruited at shopping areas, universities and public places. The sample included 103 females (51.5 %) and 97 males (48.5 %), ranging in age from 18 to 84 years (mean 37.7, standard deviation 15.2). Table 1.1 describes the characteristics of the participants by gender, age group, education, marital status, number of people in household and number of children in household. Considering the places where people were recruited, consumers could be considered to belong to the general Uruguayan middle class population.

1.2.2. Questionnaire

The Food Choice Questionnaire (FCQ) (Steptoe *et al.*, 1995) is a questionnaire developed in England almost 15 years ago (c.f. Appendix A). Thus, in order to evaluate if consumers in Uruguay, a developing Latin American country, considered all the items of the original FCQ while selecting their food a preliminary study was performed.

The original FCQ was translated into Spanish by the author and two other researchers fluent in English. A list of items was developed, containing 50 items, the 36 items from the original FCQ translated into Spanish plus 14 items that were not included in this questionnaire, generated through consideration of existing literature and discussion with nutritionists and food technologists. A group of 50 consumers, approximately 50% male and 50% female, ages ranging between 18 and 70 years were asked to read the items in the list and to indicate the items that they consider when selecting the food they eat every day. For the design of the final questionnaire, only those items that were mentioned by at least more than one consumer were considered.

Table 1.1. Demographic details of participants

	Total (n)	%
Gender		
Men	97	48.5
Women	103	51.5
Age		
18 to 29 years	68	34.0
30 to 44 years	63	31.5
45 years and more	69	34.5
Education		
Primary school only	21	10.5
High school	128	64
University	51	25.5
Marital status		
Single	112	56.0
Married	59	29.5
Divorced	22	11.0
Widowed	7	3.5
Number of people in household		
1	28	14.0
2	64	32.0
3 or more	108	54.0
Number of children in household		
0	134	67.0
1 or more	66	33.0

In the case of items having the same meaning, only one of them was considered (for example '*Takes no time to prepare*' and '*Is easy to prepare*'). Therefore, the FCQ developed by Steptoe *et al.*

(1995) was modified by adding some items and deleting some of the original items; resulting in a questionnaire with a total of 22 items. The wording of items used in the study is shown in Appendix B. Participants were asked to rate the importance of each of the 22 items of the questionnaire by endorsing the statement 'It is important to me that the food I eat everyday' using a 7-box scale labelled on the left with 'not at all important' and on the right with 'very important'. This modification was performed in order to improve the discrimination of the 4-point scale used by Steptoe *et al. (*1995). Prescott et al. (2002) also used a 7-point structured scale instead of the 4-point scale proposed by Steptoe *et al.*

In order to evaluate participants' consumption frequency of some selected food, a questionnaire consisting of nine items was used. Each item corresponded to a type of food: fruits, vegetables, milk and dairy products, meat and meat products, fish and seafood, cereals and bakery, whole cereals products, fatty food (fried food, mayonnaise, etc.), sugary foods (marmalades, sweets, etc.). Participants were asked to indicate the frequency in which they eat each of the items by using one of the following categories: one or more times a day, between four and six times a week, two to three times a week, and one or less times a week.

Socio-demographic data were also collected for participants' characterization. The questionnaire used in the study is presented in Appendix B.

1.2.3. Data analysis

In order to reduce the original items into different factors, an exploratory Principal Factor Analysis with varimax rotation was performed on the scores for the 22 items of the food choice questionnaire. Factors with eigenvalues over 1 were considered significant (Rust & Golombok, 1989). Items with loadings above 0.40 were considered significant and those above 0.50 very significant (Hair *et al.*, 1987).

For each of the factors identified in the aforementioned analysis, average factor scores were calculated by averaging unweighted ratings for individual items in each factor. Analysis of variance was performed on factor scores considering factor and consumer as fixed sources of variation. An analysis of variance (ANOVA) was also performed on individual item ratings considering item and participant as fixed sources of variance. When differences were significant, honestly significant differences were calculated using Tukey's test. A 5% significance level ($p \leq 0.05$) was considered.

For evaluating differences by socio-demographic characteristics, analysis of variance was performed on scores for each factor using the categories of each socio-demographic characteristic as fixed sources of variation.

In order to identify different food choice patterns among consumers, a hierarchical cluster analysis was performed on the centred ratings (individual median subtracted) for the 22 evaluated items using Euclidean distances and Ward's method of aggregation.

For food frequency consumption data, frequencies in each category were calculated considering the whole sample and each of the clusters identified in the food choice questionnaire data. The existence of differences between the clusters' frequency distributions was evaluated using χ^2 statistical test.

Analysis of variance was carried out on average factor scores from the Food Choice Questionnaire considering food frequency consumption categories as fixed sources of variation.

All analyses were performed using Genstat Discovery Edition 2 (VSN International, Hemel Hempstead, UK) statistical software package.

1.3. RESULTS AND DISCUSSION

1.3.1. Food Choice

1.3.1.1. Factor analysis results

An exploratory factor analysis was performed on the 22 items of the Food Choice questionnaire to reduce the original items into different factors. This analysis resulted in 7 factors which accounted for 54.48% of the variance, with eigenvalues ranging from 7.3 to 1.4. Table 1.2 summarizes the factor analysis after varimax rotation.

Factor 1 consisted of four health and nutrient content (proteins, minerals and vitamins content) related statements and was labelled as '*Health and nutritional value*'. This suggests that consumers associated proteins, vitamins and minerals with nutritious foods which could improve their health.

Factor 2 was comprised of three items related to sensory characteristics of food, so it was labelled as '*Sensory appeal'*.

Table 1.2. Item and factor loadings for the factor analysis of the food choice questionnaire

Factor and items	*Loading*	*Explained variance*
Factor 1 – Health and nutritional value		28.49%
3. Contains a lot of vitamins and minerals	0.93	
2. Contains a high nutritional value	0.76	
8. Keeps me healthy	0.62	
14. Is high in protein	0.59	
Factor 2 – Sensory appeal		9.63%
5. Tastes good	0.78	
22. Has a pleasant texture	0.76	
15. Looks nice	0.50	
Factor 3 – Weight control		4.80%
11. Helps me control my weight	0.75	
18. Is low in calories	0.71	
13. Is low in fat	0.58	
Factor 4 – Familiarity		4.48%
16. Is familiar	0.69	
19. Is from a well known brand	0.54	
17. Is made in Uruguay	0.53	
Factor 5 – Price and convenience		2.59%
9. Is not expensive	0.62	
1. Is easy to prepare	0.56	
12. Has a long shelf life	0.54	
21. Is easily available in shops and supermarkets	0.52	
Factor 6 – Feeling good and safety		2.66%
7. Makes me feel good	0.61	
6. Makes me feel safe and trusty	0.55	
Factor 7 – Natural content		1.83%
10. Contains no artificial ingredients	0.64	
4. Contains no additives	0.53	
20. Contains natural ingredients	0.53	

Item numbers refer to the order in which statements were presented in the questionnaire.

Factor 3 was labelled as '*Weight control'* as it consisted of statements related to consumption of low fat and low calorie products, showing the prevalent cultural preference for thin bodies. The item '*low in fat*' loaded on the weight control and not in the health factor. This shows that participants associated dietary fat with weight more than with healthy dietary choices, being not too much conscious of the relationship of low fat intake and cardiovascular health. This is in agreement with reports by Steptoe *et al.* (1995) for English consumers.

Factor 4 was related to familiarity and being from a well known recognized brand, and was labelled as '*Familiarity*', suggesting that consumers perceived as familiar those products made in Uruguay and from known brands.

Factor 5 was related to ease of food purchase, ease of preparation and good price, so it was labelled as '*Price and convenience*'. Price and long shelf life loaded in this factor, suggesting that consumers related these items to typically convenience characteristics such as ease of preparation and purchase.

Factor 6 was related to people feeling good and safety while eating, so it was labelled as '*Feeling good and safety*'; while Factor 7 was labelled as '*Natural content*' as it comprised statements related to the use of additives and natural ingredients, reflecting concern with the use of this type of ingredients.

1.3.1.2. Factor average scores

In order to quantify the importance of the resulting factors, scores for each factor identified in the Factor Analysis were calculated as described in Section 1.2.3, yielding values from 1 to 7. Factor average ratings are shown in Table 1.3. *'Feeling good and safety'* was the most important factor for Uruguayan consumers, followed by *'Sensory appeal'* and *'Health and nutrient content'*. This might show the importance of non-sensory factors in determining the decisions people make with respect to what they eat.

Table 1.3. Average ratings for the items of the food choice questionnaire and the factors identified in the principal factor analysis

Factor and items	*Average item score*	*Average factor score*
Factor 1 – Health and nutritional value		5.7 ^{b}
3. Contains a lot of vitamins and minerals	5.7 ^{b,c,d,e}	
2. Contains a high nutritional value	5.6 ^{c,d,e,f,g}	
8. Keeps me healthy	6.2 ^{a,b,c}	
14. Is high in protein	5.2 ^{e,f,g,h,i}	
Factor 2 – Sensory appeal		5.8 ^{b}
5. Tastes good	6.3 ^{a}	
22. Has a pleasant texture	5.5 ^{d,e,f,g}	
15. Looks nice	5.4 ^{e,f,g,h}	
Factor 3 – Weight control		4.9 ^{d}
11. Helps me control my weight	4.9 ^{h,i,j,k}	
18. Is low in calories	4.5 ^{j,k}	
13. Is low in fat	5.2 ^{e,f,g,h,i}	
Factor 4 – Familiarity		4.4 ^{e}
16. Is familiar	4.6 ^{j,k}	
19. Is from a well known brand	4.3 ^{k}	
17. Is made in Uruguay	4.3 ^{k}	
Factor 5 – Price and convenience		5.1 ^{d}
9. Is not expensive	5.1 ^{e,f,g,h,i}	
1. Is easy to prepare	4.7 ^{i,j,k}	
12. Has a long shelf life	5.1 ^{e,f,g,h,i}	
21.Is easily available in shops and supermarkets	5.2 ^{e,f,g,h,i}	
Factor 6 – Feeling good and safety		6.2 ^{a}
7. Makes me feel good	6.1 ^{a,b,c,d}	
6. Makes me feel safe and trusty	6.3 ^{a,b}	
Factor 7 – Natural content		5.4 ^{c}
10. Contains no artificial ingredients	5.4 ^{e,f,g}	
4. Contains no additives	5.1 ^{e,f,g,h,i}	
20. Contains natural ingredients	5.6 ^{c,d,e,f}	

Item numbers refer to the order in which statements were presented in the questionnaire. Different superscripts indicate significant differences ($p \leq 0.05$) according to Tukey's test.

Furthermore, the high importance of health in determining food choice suggests that consumers might be interested in consuming functional foods. Thus, this type of product could reach an important market segment in Uruguay.

As in the present study a modification of the original Food Choice Questionnaire (Steptoe *et al.*, 1995) was used (c.f. Appendixes A and B), the identified factors were not exactly the same to those reported by Steptoe *et al.* (1995) in UK, by Lindeman & Väänämen (2000) in Finland or by Prescott *et al.* (2002) in Japan, Taiwan, Malaysia and New Zealand. However, some similarities and differences could be highlighted. '*Familiarity'* was the least important factor, in agreement with results from Steptoe *et al.* (1995), Prescott *et al.* (2002) and Eertmans *et al.* (2006). This suggests that consumers are not usually concerned about eating their accustomed diet, and that this factor might not be very important in most cultures. '*Weight control'* showed a low score, in agreement with Steptoe *et al.* (1995) for English consumers. '*Sensory appeal'* and '*Health and nutritional value'* showed high perceived importance, as reported by Steptoe *et al.* (1995), Prescott *et al.* (2002) and Eertmans *et al.* (2006). These results showed that these factors are key determinants of food choices in most cultures. '*Price and convenience'* showed a lower relative importance for Uruguayan consumers than for European or Asian consumers. The lower importance given to convenience could be attributed to the fact that in Uruguay most people prepare their meals and that consumption of ready to eat products is not very important. Regarding price, it is curious that Uruguayans did not mention it as one of the most important factors. Particularly, they gave it lower importance than European consumers (Steptoe *et al.*, 2006; Eertmans *et al.*, 2006).This was not expected as Uruguayan consumers may have higher budgetary restrictions than European consumers.

1.3.1.3. Individual item scores

As shown in Table 1.3, individual item scores were averaged among consumers. The items '*Makes me feel good*', '*Makes me feel safe and trusty*', '*Keeps me healthy*' and '*Tastes good*' showed the highest relative importance, being the variables most likely to influence consumer food choices. These results are in agreement with published data and suggest that health and the sensory characteristics of foods have a high impact on consumers' choice behaviour (Steptoe *et al.*, 1995; Rozin, 1996; Lindeman & Väänänen, 2000; Prescott *et al.*, 2002; Eertmans *et al.*, 2006). This is also in agreement with conclusions drawn considering factor average scores from Section 1.3.1.2.

However, average scores from individual items from the Food Choice Questionnaire and average scores from the factors identified in the Factor Analysis provided some different information. When evaluating individual items average scores, it could be concluded that taste was as important as staying healthy or feeling good and safe, when choosing what to eat on a typical day (c.f. Table 1.3). However, scores for '*Sensory appeal*' were significantly lower than those for '*Feeling good and safety*' (c.f. Table 1.3). Therefore, not all the items within one factor had the same importance for consumers. These differences could be lost by evaluating average factor scores. Averaging information could be misleading and it could be concluded that taste does not have such an important role in determining food choice. Considering individual item scores, taste was the most important sensory attribute, being a key attribute in food choice (c.f. Table 1.3). Therefore, results suggest the importance of considering individual item scores apart from average factor scores in order to properly conclude on the factors that determine consumer food choices.

Furthermore, the high scores given to '*Makes me feel safe and trusty*' and '*Has a long shelf-life*' (c.f. Table 1.3) suggest that these were important issues for consumers when selecting their food. However, these items were not included in the original FCQ developed by Steptoe *et al.* (1995). Thus, some items that may be important for Uruguayan consumers when selecting their everyday food might not be considered in this questionnaire since it was developed in UK almost fifteen years ago. Therefore, further study should be conducted in order to evaluate the possibility of incorporating more items into the FCQ, particularly considering how quickly the food markets and consumers' needs are changing.

1.3.1.4. Differences by socio-demographic characteristics

Differences in average factor scores were studied by gender, age group, number of people in household, and number of children in household.

As shown in Table 1.4, except from '*Feeling good and safety'*, highly significant differences were found in factor scores with participants' gender. For both men and women, '*Feeling good and safety'* was the most important factor, followed by '*Sensory appeal*' and '*Health and nutritional value'*. Although women seemed to give higher scores to all factors, they showed the same choice pattern than men. This might indicate that women pay more attention to several food characteristics when choosing what to eat. The difference in ratings on the health factor is consistent with other studies, which suggests that women are more positive towards health benefits of food than men (Wardle & Steptoe, 1991; Steptoe *et al.*, 1995). The largest differences between females and males' ratings were found for '*Weight control*' and '*Price and convenience*,' with mean differences of 1.1 and 0.9 respectively.

Table 1.4. Average factor scores by gender.

Factor	Gender	
	Women	Men
1. Health and nutritional value	5.8 $^{B\ a}$	5.5 $^{B\ b}$
2. Sensory appeal	5.9 $^{A,\ B\ a}$	5.6 $^{B\ b}$
3. Weight control	5.3 $^{C\ a}$	4.4 $^{D,E\ b}$
4. Familiarity	4.8 $^{D\ a}$	4.3 $^{E\ b}$
5. Price and convenience	5.4 $^{C\ a}$	4.7 $^{D\ b}$
6. Feeling good and safety	6.2 $^{A,\ a}$	6.2 $^{A\ a}$
7. Natural content	5.6 $^{B,\ C\ a}$	5.1 $^{C\ b}$

Values within one column with different capital superscripts are significantly different according to Tukey's test ($p \leq 0.05$). Values within one row with different lowercase superscripts are significantly different according to Tukey's test ($p \leq 0.05$).

The difference in '*Price and convenience'* between women and men reflect the familiar structure of Uruguayan society, in which women are responsible for selecting what to eat and preparing meals at home. On the other hand, men do not care much for this factor, as they usually eat what women prepare. Besides, the differences in '*Weight control'* ratings reflect that women care more about their image and their weight than men.

As shown in Table 1.5, highly significant differences in the scores of all factors were found by age group. An increase in the importance of all factors with age was found. The importance of '*Health and nutritional content'* and '*Feeling good and safety'* significantly increased as age increased. This is in agreement with published data which report that older people are more health-conscious (Steptoe *et al.,* 1995; Poulsen, 1999; Bogue & Ryan, 2000).

Table 1.5. Average factor scores by age group.

Factor	Age group		
	18 to 29 years	30 to 44 years	More than 45 years
1. Health and nutritional value	5.1 $^{B\ c}$	5.8 $^{B\ b}$	6.1 $^{B\ a}$
2. Sensory appeal	5.5 $^{A\ b}$	5.8 $^{B\ a}$	6.0 $^{B\ a}$
3. Weight control	4.3 $^{D,\ E\ c}$	5.0 $^{C,D\ b}$	5.3 $^{C\ a}$
4. Familiarity	4.0 $^{E\ c}$	4.6 $^{D\ b}$	5.0 $^{C\ a}$
5. Price and convenience	4.6 $^{C,D\ b}$	5.2 $^{C\ a}$	5.3 $^{C\ a}$
6. Feeling good and safety	5.7 $^{A\ b}$	6.3 $^{A\ a}$	6.5 $^{A\ a}$
7. Natural content	4.7 $^{C\ c}$	5.5 $^{B.\ C\ b}$	5.9 $^{B\ a}$

Values within one column with different capital superscripts are significantly different according to Tukey's test ($p \leq 0.05$). Values within one row with different lowercase superscripts are significantly different according to Tukey's test ($p \leq 0.05$).

As shown in Table 1.6, the increase in the importance attributed to health in daily food selection was found in both men and women, and indicates that people give more importance to their health as they get older. The difference in the importance of health between men and women increased with age (c.f. Table 1.6), suggesting that older women might be the most health-conscious group. Moreover, the importance given to '*Price and convenience'* increased with age. This could be attributed to the fact that younger people may not be responsible for food purchase and preparation, and may eat what other people prepare at their house. Although it could have been expected that the importance of price would decrease as people get older, the opposite was found. This could be probably attributed to the fact that younger people financially depend on other people and therefore they do not take into account price in food selection.

Table 1.6. Average score for '*Health and nutritional value'* by age group for men and women.

Gender	Age group		
	18 to 29 years	30 to 44 years	More than 45 years
Men	5.0 $^{A\ c}$	5.8 $^{A\ b}$	5.8 $^{A\ a}$
Women	5.1 $^{A\ c}$	5.8 $^{A\ b}$	6.3 $^{B\ a}$

Values within one column with different capital superscripts are significantly different according to Tukey's test ($p \leq 0.05$). Values within one row with different lowercase superscripts are significantly different according to Tukey's test ($p \leq 0.05$).

Considering number of people in household, it could be stated that people that live alone tend to care more about themselves, and gave higher ratings to factors as '*Health and nutrient content'*, and 'W*eight control'* (Table 1.7). These people also gave more importance to '*Sensory appeal'* and '*Natural content'*. The higher ratings given by this group of people to '*Price and convenience'* showed that they do not want to spend much time preparing their everyday food. Therefore, people living alone tended to be more concern about food than people living with other people, probably due to the fact that they take all food-related decisions on their own.

Table 1.7. Average factor scores by number of people in household.

Factor	Number of people in household		
	1	2	3 or more
1. Health and nutritional value	5.8 $^{B\ a}$	5.5 $^{B,\ C\ b}$	5.7 $^{B\ a,b}$
2. Sensory appeal	6.2 $^{A\ a}$	5.8 $^{A,B\ b}$	5.6 $^{B\ b}$
3. Weight control	5.6 $^{B\ a}$	4.4 $^{E\ c}$	5.0 $^{C\ b}$
4. Familiarity	5.2 $^{C\ a}$	4.6 $^{D,\ E\ b}$	4.2 $^{D\ c}$
5. Price and convenience	5.8 $^{B\ a}$	4.8 $^{D\ b}$	5.0 $^{C\ b}$
6. Feeling good and safety	6.2 $^{A\ a}$	6.1 $^{A\ a}$	6.2 $^{A\ a}$
7. Natural content	5.8 $^{B\ a}$	5.2 $^{C\ b}$	5.4 $^{B\ b}$

Values within one column with different capital superscripts are significantly different according to Tukey's test ($p \leq 0.05$). Values within one row with different lowercase superscripts are significantly different according to Tukey's test ($p \leq 0.05$).

As shown in Table 1.8, no significant differences were found in factor scores with number of children in household. Although it could be expected that people with children at home would be more concerned about food, it was not observed in this case.

Table 1.8. Average factor scores by number of children in household.

Factor	Number of children in household	
	0	1 or more
1. Health and nutritional value	5.6 $^{B\ a}$	5.8 $^{B\ a}$
2. Sensory appeal	5.8 $^{B\ a}$	5.8 $^{B\ a}$
3. Weight control	4.9 $^{C,\ D\ a}$	4.9 $^{C,\ D\ a}$
4. Familiarity	4.6 $^{D\ a}$	4.6 $^{D\ a}$
5. Price and convenience	5.0 $^{C\ a}$	5.0 $^{C\ a}$
6. Feeling good and safety	6.2 $^{A\ a}$	6.2 $^{A\ a}$
7. Natural content	5.3 $^{C\ a}$	5.5 $^{B\ a}$

Values within one column with different capital superscripts are significantly different according to Tukey's test ($p \leq 0.05$). Values within one row with different lowercase superscripts are significantly different according to Tukey's test ($p \leq 0.05$).

1.3.1.5. Cluster analysis

An agglomerative hierarchical cluster analysis was carried out to identify segments of consumers that have different food choice patterns. Three clusters were identified: cluster 1 (n=75), 2 (n=50), and 3 (n=75).

As shown in Table 1.9, the clusters significantly differed in their gender and age distribution. Cluster 1 was mainly composed of men (65%) and young people, showing the lowest average age (32.9 years). 58% of women in this cluster were between 18 and 29 years old, while 47% of men in this cluster had ages in that range. Cluster 2 showed a significantly higher average age than Cluster 1 (38.1 years), and was composed by men and women living mainly in households composed of more than 3 people (Table 1.9). Finally, Cluster 3 was composed mainly by women (67%), and showed the highest average age (42.3 years). This cluster was also composed of people living alone, as 67% of them were part of this cluster.

Highly significant differences were found in the scores of the seven choice factors between the clusters (Table1.10), suggesting that the three identified clusters gave different importance to the evaluated factors, and might show different choice patterns.

Cluster 1 gave low importance to all factors except for '*Feeling good and safety'*, '*Sensory appeal'* and '*Health and nutritional value'*. This group of people did not seem to be concerned about the use of natural ingredients, the control of their weight, familiarity or the convenience of the food they eat. The low importance attributed to convenience could be explained considering that this cluster was basically composed of young people and men, who lived with other people responsible for food selection and food preparation. Therefore, they did not care about food preparation; they just eat what other person prepares at their homes. For this cluster, health and sensory appeal were the main factors governing their food choices.

Table 1.9. Demographic details of the identified clusters with different behaviour in the food choice questionnaire.

	Cluster 1 (n=75)	Cluster 2 (n=50)	Cluster 3 (n=75)	χ^2
Gender				15.4***
Men	65%	56%	33%	
Women	35%	54%	67%	
Age				22.7***
18 to 29 years	60%	34%	23%	
30 to 44 years	17%	28%	33%	
45 years and more	23%	38%	44%	
Number of people in household				14.6*
1	7%	8%	25%	
2	40%	30%	25%	
3 or more	53%	62%	50%	

(***) highly significant differences ($p \leq 0.001$); (*) significant differences ($p \leq 0.01$)

Cluster 2 gave significantly higher ratings for all factors than Cluster 1. For this cluster the most important factors in determining food choice were '*Feeling good and safety*', '*Natural content*', '*Health and Nutritional value*' and *'Sensory appeal'*. This segment of consumers seemed to be particularly concerned about the use of additives and natural ingredients, scoring this factor as high as sensory appeal and health. '*Familiarity*' and '*Price and convenience*' were the least important factors in determining food choice. Probably because this cluster was composed of men and women who are not in charge of food preparation and women who do not care about this and really enjoy spending time in preparing their families' food.

Table 1.10. Average factor scores for each of the three consumer segments identified by cluster analysis performed on the results of the food choice questionnaire.

Factor	Cluster 1 (n=75)	Cluster 2 (n=50)	Cluster 3 (n=75)
1. Health and nutritional value	4.8 $^{C\ c}$	5.9 $^{A\ b}$	6.4 $^{A,\ B\ a}$
2. Sensory appeal	5.2 $^{B\ c}$	5.8 $^{A,\ B\ b}$	6.3 $^{A,\ B,\ C\ a}$
3. Weight control	3.5 $^{E\ c}$	5.4 $^{B\ b}$	5.9 $^{C\ a}$
4. Familiarity	4.0 $^{D\ c}$	4.7 $^{C\ b}$	5.1 $^{D\ a}$
5. Price and convenience	4.3 $^{D\ c}$	4.8 $^{C\ b}$	5.9 $^{C\ a}$
6. Feeling good and safety	5.7 $^{A\ b}$	6.2 $^{A\ b}$	6.7 $^{A\ a}$
7. Natural content	4.1 $^{D\ b}$	6.1 $^{A\ a}$	6.1 $^{B,\ C\ a}$

Values within one column with different capital superscripts are significantly different according to Tukey's test ($p \leq 0.05$). Values within one row with different lowercase superscripts are significantly different according to Tukey's test ($p \leq 0.05$).

Cluster 3 gave the highest scores to all factors ($p<0.05$), except for '*Natural content*', which could be attributed to a higher involvement or might suggest that food choice for this group was governed by multidimensional reasons that included health, sensory appeal, price and convenience, as well as natural content. For this cluster the most important factors were '*Feeling good and safety'*, '*Health and nutritional value'* and *'Sensory appeal'*. This group gave significantly higher ratings to *weight control* than the other clusters, showing a higher concern about their image. Moreover, they seemed to be particularly concerned about '*Price and convenience'*, scoring this factor approximately 1.3 points higher than the rest of the clusters, probably because they are in charge of food preparation and selection at their homes, or because they had a lower income. This variation in the relative importance of different factors for different segments of the population may make it possible to create food with different profiles for each of these distinct groups. In particular, women and older people seemed more interested in food products with a positive impact on their health and might be the target consumer segment for functional foods.

1.3.2. Food Consumption Frequency

Consumption frequency distribution for different food types are shown in Table 1.11. As shown in this Table, 55% of the sample ate less than one fruit and vegetable per day. The World Health Organization suggested a daily intake of 400 g of vegetables and fruits (World Health Organization, 2003), in response to which many food-health campaigns (e.g. five-a-day) were launched to promote the intake of vegetables and fruits during the nineties in many countries (Cox *et al.*, 1996). However, no public campaigns have been implemented in Uruguay to promote health and vegetables consumption.

Despite clinical evidence and effective public health campaigns (Cox *et al.*, 1998), vegetable and fruit consumption remains below recommended daily intake in many countries due to barriers such as complacency and lack of willpower to change the diet (Marshall *et al.*, 1994; Thompson *et al.*, 1999, Wardle *et al.*, 2000).

Table 1.11. Food frequency consumption of selected food types, for the whole sample and the three clusters from food choice questionnaire.

	Whole sample (n=200)	Cluster 1 (n=75)	Cluster 2 (n=50)	Cluster 3 (n=75)	χ^2
Fruits					12.5*
One or more times a day	45	32	50	55	
Between four and six times a week	14	17	10	13	
Two to three times a week	28	37	32	17	
One or less times a week	13	13	8	15	
Vegetables					15.2*
One or more times a day	45	35	46	55	
Between four and six times a week	26	31	36	16	
Two to three times a week	20	28	10	17	
One or less times a week	9	7	8	12	
Milk and dairy products					1.7 ^{ns}
One or more times a day	72	71	76	71	
Between four and six times a week	13	13	14	12	
Two to three times a week	11	12	6	12	
One or less times a week	5	5	4	5	
Meat and meat products					7.0 ^{ns}
One or more times a day	14	13	12	16	
Between four and six times a week	39	48	42	28	
Two to three times a week	35	29	34	40	
One or less times a week	12	9	12	16	

(***) highly significant differences ($p \leq 0.001$); (*) significant differences ($p \leq 0.01$); ^{ns} - no significant differences ($p > 0.05$)

Besides, the consumption of whole cereals is rather scarce in Uruguay, as approximately 56% of the sample eats whole cereals one or less times a week. Regarding consumption of fish and seafood, 82% of the sample eats less than one serving of fish and seafood a week, falling bellow the recommendations (World Health Organization Study Group, 1990; World Health Organization, 2003). On the other hand, large amounts of milk and dairy products and cereals and bakery are consumed, with 72% and 59% of the sample respectively who eat these products once a day or more. Therefore, these results suggest that public health campaigns might be necessary in Uruguay to change dietary choices and encourage the consumption of healthier foods, such as fruits, vegetables, fish and seafood, and whole cereals.

Table 1.11 (cont.). Food frequency consumption of selected food items, for the whole sample and the three clusters from food choice questionnaire.

	Whole sample (n=200)	Cluster 1 (n=75)	Cluster 2 (n=50)	Cluster 3 (n=75)	χ^2
Fish and seafood					5.7 ^{ns}
One or more times a day	0	0	0	0	
Between four and six times a week	3	3	1	4	
Two to three times a week	16	9	24	16	
One or less times a week	82	88	74	80	
Cereals and bakery					5.0 ^{ns}
One or more times a day	59	52	68	59	
Between four and six times a week	21	28	16	19	
Two to three times a week	13	13	8	15	
One or less times a week	8	7	8	8	
Whole cereals products					19.9**
One or more times a day	15	9	16	24	
Between four and six times a week	16	9	20	19	
Two to three times a week	13	13	12	36	
One or less times a week	56	68	52	47	
Fatty foods					3.8 ^{ns}
One or more times a day	10	12	10	8	
Between four and six times a week	20	20	20	20	
Two to three times a week	32	37	28	28	
One or less times a week	38	31	42	44	
Sugary foods					11.3 ^{ns}
One or more times a day	25	29	28	19	
Between four and six times a week	30	28	28	32	
Two to three times a week	24	32	18	21	
One or less times a week	21	11	26	28	

(***) highly significant differences ($p \leq 0.001$); (*) significant differences ($p \leq 0.01$); ^{ns} - no significant differences ($p > 0.05$)

Despite consumers attributed a high importance to health related issues, a large gap existed between their food intake and dietary recommendations. This could be attributed to the fact that consumers were not aware of dietary recommendations. This discrepancy between dietary recommendations and actual food intake has been reported by other authors (Lloyd *et al.*, 1993; Sparks *et al.*, 1995; Lappalainen *et al.*, 1998). These authors have explained the gap considering that consumers may not see recommendations as personally relevant for them because they think their diet is healthy enough (Lappalainen *et al.*, 1998) or that most consumers are unrealistically optimistic about diet-related health risks (Sparks *et al.*, 1995). Therefore, consumers might be unwilling to change their diet. For this reason, the development of functional and nutritionally modified products could be an alternative to achieve positive health effects on consumers (Kähkönen, 2000).

As previously discussed, participants showed a low intake of fruits, vegetables and whole cereals. This suggests that their intake of fibre and antioxidant compounds might be below the recommendations. Thus, the development of foods enriched with fibre and antioxidants could be an alternative to improve their health status.

The development of functional foods should be carried out considering base products that are frequently consumed in relative large amounts, in order to achieve positive health effects. Thus, as shown in Table 1.11, dairy products and bakery were the food categories with the largest frequency consumption. Therefore, these products could consist on interesting carriers for the development of functional foods, particularly functional foods enriched with fibre or antioxidants.

As shown in Table 1.11 significant differences in the consumption frequency of fruits and vegetables were found between clusters. Clusters 2 and 3 showed a significantly higher consumption frequency of fruits, vegetables and whole cereals than Cluster 1. As these clusters differed in their food choice patterns, these results might suggest the influence of motives underlying food choice in food frequency consumption. In particular, Cluster 3 gave the highest scores to '*Health and nutrient content'*, followed by Cluster 2 and finally Cluster 1. Therefore, the intake of fruits, vegetables and whole cereals increased as the importance attributed to health increased.

In order to find out if the different factors identified in the food choice questionnaire had any influence on frequency consumption of the selected food items, average factor scores from Food Choice Questionnaire for each of the evaluated consumption frequencies of the selected products were calculated. ANOVA was carried out on average factor scores considering food frequency consumption frequency categories as variation factor.

As shown in Table 1.12, the scores given to '*Health and nutrition'* significantly increased as consumption frequency of fruits, vegetables, milk and dairy products and whole cereals increased; being the intake of these types of food associated with healthy food choices. On the other hand, as consumption frequency of greasy foods increased, '*Health and nutrition'* and 'W*eight control' scores* decreased. This might suggest that consumption of some kinds of food, especially those perceived as healthy or unhealthy, depend on how concerned consumers are for health and nutritional content issues.

Table 1.12. Average scores for the factors in the Food Choice Questionnaire as a function of food frequency consumption categories of selected food items and F-ratio in the Analysis of variance carried out considering frequency categories as fixed sources of variation.

	One or more times a day	Between four and six times a week	Two to three times a week	One or less times a week	F-ratio
Fruits					
Health and nutritional value	6.0 ^{a}	5.7 ^{a,b}	5.3 ^{b}	5.1 ^{b}	7.1***
Sensory appeal	5.8 ^{a}	5.4 ^{a}	5.8 ^{a}	5.9 ^{a}	1.4 ^{ns}
Weight control	5.1 ^{a}	4.5 ^{a}	4.8 ^{a}	4.6 ^{a}	1.5 ^{ns}
Familiarity	4.7 ^{a}	4.2 ^{a}	4.5 ^{a}	4.9 ^{a}	1.6 ^{ns}
Price and convenience	5.2 ^{a}	4.5 ^{a}	4.9 ^{a}	5.3 ^{a}	2.6 ^{ns}
Feeling good and safety	6.2 ^{a}	5.9 ^{a}	6.2 ^{a}	6.5 ^{a}	2.0 ^{ns}
Natural content	5.7 ^{a}	5.3 ^{a,b}	5.0 ^{b}	5.0 ^{b}	3.9 **
Vegetables					
Health and nutritional value	6.0 ^{a}	5.7 ^{a,b}	5.6 ^{b}	5.2 ^{b}	4.9 **
Sensory appeal	5.8 ^{a}	5.8 ^{a}	5.7 ^{a}	5.9 ^{a}	0.2 ^{ns}
Weight control	4.9 ^{a}	4.9 ^{a}	4.7 ^{a}	5.0 ^{a}	0.2 ^{ns}
Familiarity	4.6 ^{a}	4.7 ^{a}	4.6 ^{a}	4.3 ^{a}	0.2 ^{ns}
Price and convenience	5.0 ^{a}	4.8 ^{a}	5.3 ^{a}	5.4 ^{a}	1.4 ^{ns}
Feeling good and safety	6.2 ^{a}	6.1 ^{a}	6.2 ^{a}	6.2 ^{a}	0.2 ^{ns}
Natural content	5.6 ^{a}	5.3 ^{a,b}	5.1 ^{b}	4.9 ^{b}	2.6 *
Milk and dairy products					
Health and nutritional value	5.7 ^{a}	5.6 ^{a}	5.5 ^{a,b}	5.2 ^{b}	3.2 *
Sensory appeal	5.7 ^{a}	5.8 ^{a}	5.9 ^{a}	6.0 ^{a}	0.3 ^{ns}
Weight control	4.8 ^{a}	4.6 ^{a}	5.1 ^{a}	5.7 ^{a}	1.2 ^{ns}
Familiarity	5.2 ^{a}	4.7 ^{a}	4.6 ^{a}	5.0 ^{a}	1.0 ^{ns}
Price and convenience	5.0 ^{a}	5.0 ^{a}	4.9 ^{a}	5.9 ^{a}	1.6 ^{ns}
Feeling good and safety	6.1 ^{a}	6.3 ^{a}	6.4 ^{a}	6.4 ^{a}	0.6 ^{ns}
Natural content	5.4 ^{a}	5.5 ^{a}	5.2 ^{a}	5.1 ^{a}	0.4 ^{ns}

Means with different superscripts within one row indicate significant difference ($p \leq 0.05$). (***) highly significant differences ($p \leq 0.001$); (**) very significant differences ($p \leq 0.01$); significant differences ($p \leq 0.05$); ^{ns} - no significant differences ($p > 0.05$).

Table 1.12 (cont.). Average scores for the factors in the Food Choice Questionnaire as a function of food frequency consumption categories of selected food items and F-ratio in the Analysis of variance carried out considering frequency categories as fixed sources of variation.

	One or more times a day	Between four and six times a week	Two to three times a week	One or less times a week	F-ratio
Meat and meat products					
Health and nutritional value	5.8^{a}	5.4^{a}	5.8^{a}	5.8^{a}	2.2^{ns}
Sensory appeal	5.7^{a}	5.7^{a}	5.9^{a}	5.8^{a}	0.4^{ns}
Weight control	4.6^{a}	4.7^{a}	5.0^{a}	5.5^{a}	1.8^{ns}
Familiarity	4.7^{a}	4.5^{a}	4.6^{a}	4.6^{a}	0.1^{ns}
Price and convenience	5.1^{a}	5.0^{a}	5.0^{a}	5.2^{a}	0.3^{ns}
Feeling good and safety	6.4^{a}	6.2^{a}	6.2^{a}	6.1^{a}	0.6^{ns}
Natural content	5.5^{a}	5.1^{a}	5.6^{a}	5.7^{a}	1.5^{ns}
Fish and seafood					
Health and nutritional value	6.0^{a}	5.1^{a}	6.1^{a}	5.7^{a}	1.8^{ns}
Sensory appeal	5.8^{a}	6.9^{a}	5.8^{a}	5.7^{a}	1.2^{ns}
Weight control	4.1^{a}	6.1^{a}	5.0^{a}	4.8^{a}	0.9^{ns}
Familiarity	4.7^{a}	4.0^{a}	4.4^{a}	4.6^{a}	0.5^{ns}
Price and convenience	4.5^{a}	4.8^{a}	4.7^{a}	5.1^{a}	1.0^{ns}
Feeling good and safety	6.2^{a}	6.2^{a}	6.5^{a}	6.1^{a}	1.5^{ns}
Natural content	5.1^{a}	6.2^{a}	5.7^{a}	5.3^{a}	1.2^{ns}
Cereals and bakery					
Health and nutritional value	5.8^{a}	5.4^{a}	5.8^{a}	5.4^{a}	1.3^{ns}
Sensory appeal	5.8^{a}	5.7^{a}	5.9^{a}	5.9^{a}	0.4^{ns}
Weight control	4.9^{a}	4.7^{a}	4.9^{a}	4.8^{a}	0.2^{ns}
Familiarity	4.6^{a}	4.4^{a}	4.6^{a}	4.8^{a}	0.4^{ns}
Price and convenience	5.0^{a}	5.0^{a}	5.0^{a}	5.2^{a}	0.1^{ns}
Feeling good and safety	6.2^{a}	6.1^{a}	6.5^{a}	6.1^{a}	2.0^{ns}
Natural content	5.4^{a}	5.6^{a}	5.5^{a}	5.2^{a}	1.0^{ns}
Whole cereals					
Health and nutritional value	6.0^{a}	6.0^{a}	$5.7^{a,b}$	5.5^{b}	2.7 *
Sensory appeal	5.5^{a}	6.0^{a}	5.7^{a}	5.8^{a}	1.1^{ns}
Weight control	5.5^{a}	5.27^{a}	$4.7^{a,b}$	4.7^{b}	2.8 *
Familiarity	4.7^{a}	4.9^{a}	4.4^{a}	4.5^{a}	1.0^{ns}
Price and convenience	5.0^{a}	5.0^{a}	4.9^{a}	5.1^{b}	0.2^{ns}
Feeling good and safety	6.5^{a}	6.4^{a}	5.9^{a}	6.2^{a}	2.4^{ns}
Natural content	5.7^{a}	5.8^{a}	5.7^{a}	5.1^{a}	2.5^{ns}

Means with different superscripts within one row indicate significant difference ($p \leq 0.05$). (***) highly significant differences ($p \leq 0.001$); (**) very significant differences ($p \leq 0.01$); significant differences ($p \leq 0.05$); ^{ns} - no significant differences ($p > 0.05$).

Table 1.12 (cont). Average scores for the factors in the Food Choice Questionnaire as a function of food frequency consumption categories of selected food items and F-ratio in the Analysis of variance carried out considering frequency categories as fixed sources of variation.

	One or more times a day	Between four and six times a week	Two to three times a week	One or less times a week	F-ratio
Fatty foods					
Health and nutritional value	5.3 [b]	5.4 [b]	5.7 [b]	6.0 [a]	4.0 **
Sensory appeal	5.6 [a]	6.1 [a]	5.6 [a]	5.8 [a]	1.7 [ns]
Weight control	4.0 [c]	4.6 [b,c]	4.8 [a,b]	5.3 [a]	3.9 **
Familiarity	4.4 [a]	4.9 [a]	4.5 [a]	4.6 [a]	1.6 [ns]
Price and convenience	4.6 [a]	5.1 [a]	4.7 [a]	5.1 [a]	2.0 [ns]
Feeling good and safety	6.4 [a]	6.3 [a]	6.1 [a]	6.1 [a]	0.6 [ns]
Natural content	4.7 [b]	5.1 [b]	5.3 [b]	5.8 [a]	4.0 **
Sugary foods					
Health and nutritional value	5.7 [a]	5.7 [a]	5.4 [a]	5.9 [a]	1.6 [ns]
Sensory appeal	5.7 [a]	5.7 [a]	5.8 [a]	6.0 [a]	0.8 [ns]
Weight control	5.0 [a]	5.0 [a]	5.2 [a]	5.5 [a]	2.0 [ns]
Familiarity	4.5 [a]	4.7 [a]	4.4 [a]	4.8 [a]	0.8 [ns]
Price and convenience	4.9 [a]	5.1 [a]	4.8 [a]	5.4 [a]	1.5 [ns]
Feeling good and safety	6.3 [a]	6.0 [a]	6.2 [a]	6.4 [a]	0.4 [ns]
Natural content	5.2 [a]	5.3 [a]	5.4 [a]	5.8 [a]	1.4 [ns]

Means with different superscripts within one row indicate significant difference ($p \leq 0.05$). (***) highly significant differences ($p \leq 0.001$); (**) very significant differences ($p \leq 0.01$); significant differences ($p \leq 0.05$); [ns] - no significant differences ($p > 0.05$).

As consumption frequency of fruits and vegetables increased, the importance attributed to '*Natural content'* significantly increased, suggesting that people interested in the selection of natural ingredients, might show a higher intake of these products. Therefore, consumption of fruits and vegetables could be increased by increasing consumers' concern about health and nutrition issues and about the consumption of natural products.

For whole cereals and greasy foods, significant differences were found in scores for '*Weight control*'. Increasing '*Weight control*' scores were found as consumption of greasy foods decreased and consumption of whole cereals increased.
No significant (p>0.05) differences were found in the average scores of the seven factors identified in the food choice questionnaire between consumers with different food frequency consumption of meat and meat products, fish and seafood, cereals and bakery, and sugary foods (c.f. Table 1.12). Thus, consumers with different consumption frequency of these food products did not differ in the importance they gave to the identified factors. These results suggest that consumption frequency of these food products could not be explained by considering only the food choice questionnaire factors, and that other motives might influence the existing differences in their consumption frequencies.
For all the selected food categories, no significant differences were found in the scores of the factors related to '*Sensory appeal*', '*Feeling good and safety*', '*Price and convenience*', and '*Familiarity*', among the different food consumption frequencies. This suggests that these factors might not influence consumption frequency of these groups of foods and might have a greater influence in determining which particular types of foods are consumed.
Results showed that food selection may be influenced by motives for food choice, especially those related to health and nutrition; suggesting the great importance of this factor in consumers' everyday food selection. These factors may influence consumption frequency of certain food categories, particularly those foods

perceived as healthy or unhealthy. Further research is needed in order to better understand the influence of motives underlying food choice in food consumption.

1.4. CONCLUSIONS

'Feeling good and safety', '*Sensory appeal'* and '*Health and nutrient content'* were rated as the most important factors, while '*Familiarity'* was rated as the least important. Considering the importance of health on consumer food choices, the development of functional foods could be an alternative for food companies to achieve an interesting consumer segment in Uruguay. Functional foods with good sensory and hedonic characteristics would satisfy consumers' most important factors when selecting food products: sensory appeal and health and nutritional content.

This variation in the relative importance of different factors for different segments of the population may make it possible to create food with different profiles for each of these distinct groups.

Consumption frequencies of fruits, vegetables, milk and dairy products, whole cereals, and fatty foods were related to the importance that people give to health and nutritional content in their food choices. Considering the status of health in food choice, marketing and government health promoting strategies that help recognize the effects of diet on health, might change food selection patterns towards healthier dietary choices.

Considering consumers' dietary patterns, the development of functional foods enriched with fibre and antioxidants could be an alternative to improve their health status. These functional ingredients should be added to dairy or bakery products, as they were the food categories most frequently consumed.

CHAPTER 2

UNDERSTANDING URUGUAYAN CONSUMERS' PERCEPTION OF FUNCTIONAL FOODS

ABSTRACT

The aim of the present chapter was to study Uruguayan consumers' perception of functional foods. A survey with 200 participants was performed in order to evaluate consumers' attitudes towards functional foods. Participants were not familiar with the term 'functional food', as only 38% related the term with the real concept behind it. However, they showed a positive attitude towards the concept behind functional foods, as they were interested in consuming food products with a positive impact on their health. Cardiovascular diseases, cancer and the immune system were regarded as the preferred areas of action of functional foods. Furthermore, consumers perceptions of conventional (regular plain yogurt, low-calorie and low-fat yogurt) and functional yogurts (enriched with fibre and antioxidants) were studied using word association and hard laddering. Both methodologies indicated that consumers' perceptions of these products were mainly related to health, nutrition, sensory characteristics and pleasure. Consumers' motivations for consuming functional yogurts were mainly related to their positive influence on health. Results from the present chapter suggested that Uruguayan consumers might be interested in consuming functional foods, particularly those enriched with fibre or antioxidants.

2.1. INTRODUCTION

The markets for functional foods are increasing. New products are continuously launched and competition is becoming more intense (Menrad, 2003). As consumers have more and more choices available to them, functional foods need to be developed in line with consumers' needs and wants. However, there is surprisingly little scientific research available to support food companies in determining which functional foods to develop (van Kleef *et al.*, 2005).

Studying and understanding consumers' perception of functional foods is essential to develop products which show good consumer acceptance. Information about consumers' perception of functional foods is particularly important for the development of this type of product in small markets like Uruguay. Functional products have been increasingly launched in the market in the past two or three years. However, food companies do not have information about consumers' perception of these products and do not know if consumers will embrace them as enthusiastically as they hope for. Published studies about consumers' perception of functional foods have been performed in the U.S.A. and Europe. No study has been found reporting the attitude of Latin-American consumers toward this food category. Therefore, one important question is if consumers in developing countries will behave similarly to their developed country counterparts.

Health is one of the factors that influence consumers' food choices (Steptoe *et al.*, 1995; Jaeger, 2006). In the case of functional foods, consumers' attitudes towards health are likely to be central in determining their acceptance (Urala & Lähteenmäki, 2003; 2004; Jaeger, 2006). Consumers can only be expected to consider consuming functional foods instead of their conventional counterparts if they are perceived as comparatively healthier. For this reason, the perception of the relative importance of various health-promoting behaviors could have potential implications for the acceptance of functional foods (Bech-Larsen *et al.*, 2001). Understanding issues such as how much consumers think they are in control of their health and the importance of diet in general health condition could influence the acceptance of functional foods (Pachter *et al.* 2000), as it is the main motivation for using functional foods.

Research is necessary to gather information about which functional products consumers are interested in. Thus, when developing a new functional food, information regarding consumers' healthiness perception and which health claims consumers focus on is needed (Verbeke, 2005). According to van Kleef *et al.* (2005) one of the first steps of functional foods development is to explore which diseases consumers are concerned about. In this context, the perceived seriousness of various diseases is important as this could potentially influence the acceptance of functional foods designed to prevent certain types of illnesses (Hilliam, 1998). Consumers will be willing to consume a particular functional food if they are interested in its claimed effect on health.

Qualitative techniques are suitable tools in the first stages of new product development for revealing consumers' perceptions of new concepts or food products (Roininen *et al.*, 2006). Some of the techniques that could be useful for this purpose are word association and laddering techniques.

Word association is one of the most commonly used methods for the evaluation of conceptual structures and also for studying beliefs or attitudes in psychology and sociology (Doise *et al.*, 1993; Schmitt, 1998; Hirsh & Tree, 2001; Ross, 2003; Hovardas & Korfiatis, 2006). It is based on Free Association, a key component of Freudian technique of psychoanalysis (Laplanche & Pantalis, 1971). In this methodology participants are given a stimulus and are asked to respond with the first words (i.e. associations) that come to their minds. Word association is based on the assumption that giving a stimulus concept or object and asking the respondent to freely associate what ideas come to his or her mind gives relatively unrestricted access to mental representations of the stimulus term. According to expectancy-value theories of Ajzen & Fishbein (1980), most of the first associations or beliefs that the consumer has about a concept are closely related to consumer's actual behaviour related to that concept. In the case of food products, the associations that first come to the respondents' mind might be the ones that should be the most relevant for consumers' choice and their decisions related to product purchase (Roininen *et al.*, 2006). It has been declared that ideas expressed within a word association procedure are spontaneous, thus subject to fewer constraints than that typically imposed in interviews or closed questionnaires (Wagner *et al.*, 1996). Therefore, this technique could provide a fast and convenient tool for exploring the motives behind food choices or consumers' perceptions of food products, including new and undefined food concepts. This method has not been much used for understanding consumers' perceptions of foods. The first application of this method to food concepts was reported by Roininen *et al.* (2006) who applied this methodology to understand consumers' perception of local and organic foods. However, more studies are necessary in order to evaluate the applicability of word association for the evaluation of consumers' perception of food products.

Laddering techniques have been applied to understand consumers' perceptions of food products and their motivations for their food choices (Reynolds & Gutman, 1988). This methodology is based on the Means-end-chain theory (M-E-C), which describes linkages between product attributes, the consequences for the consumer provided by these attributes, and the personal values the consequences reinforce (Reynolds & Gutman, 1988). There are two main alternatives of laddering, soft and hard laddering. While soft-laddering is based on a personal interview performed by a highly trained interviewer, hard laddering relies upon a structured questionnaire (Botschen & Thelen, 1998; Russell *et al.*, 2004a; Russell *et al.*, 2004b). Hard laddering has been claimed to provide similar results than soft laddering, but overcoming some of the limitations of the former, such as reducing time and cost of administration and minimizing the influence of the interviewer (Grunert & Grunert, 1995; Botschen & Thelen, 1998; Russell *et al.*, 2004a; 2004b).

Word association and laddering techniques might provide different results. In word association participants are asked about concepts, images and thoughts that come into their mind for each product. Thus, this methodology is likely to yield conscious thoughts and associations about the products, after being individually considered and evaluated. On the other hand, when consumers carry out a laddering task they are usually asked to compare the concepts, products or attributes and then elicit their reasons for choosing a certain product for purchase or consumption. Thus, laddering methods are likely to yield more unconscious concepts and associations that are mainly related to consumers' preferences and reasons behind their choices. For the above mentioned reasons, word association could provide conscious and affective concepts whereas laddering constructs are mainly more related to evaluative/cognitive ones

The aims of the present chapter were: **(a)** to get a first insight into Uruguayan consumers' attitude towards functional foods and **(b)** to gather information about consumers' perception of conventional and functional yogurts using word association and hard laddering.

2.2. CONSUMERS' ATTITUDES TOWARDS FUNCTIONAL FOODS

2.2.1. MATERIALS AND METHODS

2.2.1.1. Subjects and material

Data was collected through a survey with 203 consumers, who were randomly recruited at shopping areas, universities and public places. The sample included 106 females (52.2 %) and 97 males (47.8 %), ranging in age from 19 to 78 years (mean 37.4, standard deviation 14.2). Considering the places where participants were recruited, the sample is assumed to be part of the general middle class Uruguayan population.

Participants were asked to fill the questionnaire shown in Appendix C. They had to complete some socio-demographic information, answer some open-ended and multiple choice questions; and they had to rate the importance on their health of some factors using a 7-box scale labeled on the left with 'not at all important' and on the right with 'very important'.

Consumers were asked to indicate their preferred areas of action of functional foods. Eight health benefits were chosen, comprising the most important causes of death in Uruguay (MSP, 2003), some of the health claims considered in Japanese legislation (Shimizu, 2003) and those considered in other work (Bech-Larsen *et al.*, 2001). The selected health benefits considered were: prevent cardiovascular diseases, lower cholesterol, lower blood pressure, prevent osteoporosis, prevent cancer, enhance the immune system, slimming effect, prevent anemia, and increase healthy gut bacteria.

2.2.1.2. Data analysis

Analysis of variance (ANOVA) was performed on data from perceived importance of different factors on health, considering each factor and consumer as fixed sources of variation. For evaluating differences by socio-demographic characteristics (age, gender and educational qualification), analysis of variance for each factor was performed on scores using the categories of each socio-demographic characteristic as variation factor. When the effects were significant, honestly significant differences were calculated using Tukey's test. Differences were considered significant when $p \leq 0.05$.

For multiple choice questions, frequency of mention of each category was calculated. The existence of differences between gender and age was evaluated using χ^2 statistical test.

All statistical analyses were performed using Genstat Discovery Edition 2 (VSN International, Hemel Hempstead, UK).

2.2.2. RESULTS AND DISCUSSION

2.2.2.1. Impact of different aspects on health

Average ratings for the six evaluated factors are shown in Table 2.1. A wholesome and varied diet, avoiding smoking and stress, as well as regular exercise, were seen by consumers as the most decisive factors affecting their health. According to Bech-Larsen *et al.* (2001), Finnish, Danish and American consumers considered a wholesome and varied diet and regular exercise as the two factors having the greatest impact on their health. Therefore, the studied sample of Uruguayan consumers seemed to give more importance to avoiding smoking and avoiding stress, considering them as important as diet and exercise.

The perception of the relative importance of various health promoting benefits could affect consumers' acceptance of functional foods (Bech-Larsen *et al.*, 2001). In this case, the high importance attributed to diet suggests that it is a decisive factor in consumers' mind in relation to maintaining their health. This might have potential implications for the acceptance of functional foods. Considering that consumers think that food highly affect their health status, they might have a positive attitude towards functional foods and might consider the possibility of consuming them for achieving a positive effect on their health.

Table 2.1. Average ratings for the importance of various factors on health for the whole sample, by gender and age.

Factor	Average importance					
		Gender		Age		
	Whole sample	Female	Male	18 to 29 years	30 to 44 years	More than 45 years
Regular exercise	6.4 ^{A}	6.4 $^{A\ a}$	6.5 $^{A\ a}$	6.1 $^{A\ b}$	6.7 $^{A\ a}$	6.5 $^{A\ a}$
Avoid smoking	6.5 ^{A}	6.5 $^{A\ a}$	6.5 $^{A\ a}$	6.4 $^{A\ a}$	6.4 $^{A\ a}$	6.6 $^{A\ a}$
Genetic	5.3 ^{B}	5.3 $^{B\ a}$	5.4 $^{C\ a}$	4.9 $^{C\ a}$	5.1 $^{B\ b}$	5.9 $^{B\ c}$
Avoid stress	6.2 ^{A}	5.2 $^{B\ b}$	6.3 $^{A\ a}$	5.7 $^{B\ b}$	6.4 $^{A\ a}$	6.6 $^{A\ a}$
Avoid drinking alcohol	4.9 ^{C}	5.0 $^{B\ a}$	4.8 $^{D\ a}$	4.4 $^{D\ b}$	4.6 $^{C\ b}$	5.7 $^{B\ a}$
Wholesome and varied diet	6.2 ^{A}	6.5 $^{A\ a}$	5.9 $^{B\ b}$	6.0 $^{A,\ B\ b}$	6.5 $^{A\ a}$	6.3 $^{A\ a}$

Means within one column with different capital superscripts are significantly different according to Tukey's test ($p \leq 0.05$). Means with different lowercase superscripts within a row for different gender and age categories are significantly different ($p \leq 0.05$) according to Tukey's test. Factors were evaluated using a 7-box scale varying from 'not at all important' to 'very important'.

The relatively lower importance attributed to genetic factors could be attributed to lack of knowledge and awareness or to the fact that consumers think that they are in control of their health status.

Women gave a significantly higher importance to diet on health than men, suggesting that women can be more positive towards the health benefits of food than men (c.f. Table 2.1). Thus, women might be more prone to have a balanced diet and to accept functional foods. Men did not include diet as one of the most decisive factor in maintaining their health. These results are in agreement with those presented in Chapter 1 and with those reported by Wardle & Steptoe (1991) and Steptoe *et al.* (1995).

Besides, except for avoid smoking, the importance attributed to most of the evaluated factors significantly increased with age (Table 2.1). Older people seemed to give more importance to all factors, suggesting a higher concern about their health.

Table 2.2. Average ratings for the importance of various factors on health for the whole sample, by educational qualification.

Factor	Percentage of mentions (%)		
	Primary school	**Secondary school**	**University degree**
Regular exercise	6.5 $^{B\ a}$	6.3 $^{A\ a}$	6.6 $^{A\ a}$
Avoid smoking	7.0 $^{A\ a}$	6.3 $^{A\ b}$	6.7 $^{A\ a,b}$
Genetic	5.3 $^{C\ a}$	5.3 $^{B\ a}$	5.4 $^{B\ a}$
Avoid stress	6.1 $^{B\ a}$	6.2 $^{A\ a}$	6.3 $^{A\ a}$
Avoid drinking alcohol	5.2 $^{C\ a}$	4.7 $^{C\ a}$	5.3 $^{B\ a}$
Wholesome and varied diet	5.6 $^{C\ b}$	6.2 $^{A\ a}$	6.5 $^{A\ a}$

Means within one column with different capital superscripts are significantly different according to Tukey's test ($p \leq 0.05$). Means with different lowercase superscripts within a row are significantly different ($p \leq 0.05$) according to Tukey's test. Factors were evaluated using a 7-box scale varying from 'not at all important' to 'very important'.

On the other hand, the importance attributed to having a wholesome and varied diet on health increased with educational qualification, as people who have only completed primary school rated diet with a significantly lower importance than people who completed secondary school or had a university degree (Table 2.2). These results suggest that higher educational qualification, and therefore higher nutritional knowledge, might lead to healthier dietary choices. Thus, public health campaigns could be useful to change dietary choices towards the consumption of healthier foods.

2.2.2.2. Functional foods concept

When asked if they have ever heard the term ‘functional food’, 87.5 % of the participants responded that they had never heard it before, showing the low familiarity of Uruguayan consumers with this type of food. Uruguayan functional foods’ market is growing and there are several types of enriched and fortified products, and even some products that are commercialized with health claims. However, companies and media campaigns do not usually mention the term ‘functional food’.

Consumers were asked to give their opinion about what functional foods are. The given descriptions were sorted into five groups. Thirty-eight percent of the participants associated functional foods with foods that have some influence on health, 23% with foods modified in their nutrient content, 22% with foods easy to prepare, 9% with foods having some defined function, and 6% of the respondents gave descriptions that could not be sorted in any of the previously mentioned categories. Table 2.3 gives a more detailed description of the associations. As shown, only 60% of the participants associated functional foods with health and nutrient content related concepts, whereas only 38% related the real concept behind the term. The lack of familiarity with the term ‘functional food’ is in agreement with other studies performed in developed countries (Labrecque *et al.*, 2006; Hilliam, 1999; Krygier, 2007; Szakály *et al.*, 2004; Siró *et al.*, 2008).

These results show that new functional food products should not be promoted as functional foods without saying what this term really means.

Table 2.3. Consumers' descriptions of functional foods when asked to give their opinion about what functional foods are. Percentage of consumers that gave descriptions in each category for the whole consumer sample and by gender.

Category	Percentage of consumers (%)		
	Whole consumer sample	Gender	
		Female	Male
Health	38	43	32
Foods that have some beneficial effect on health			
A healthy food			
Foods that are necessary to maintain our health			
Foods that have a positive effect on our health			
Foods that have an effect on some aspect of our health			
Nutrient content	23	11	37
Foods that are rich in vitamin			
Foods that are rich in nutrients			
Foods that are nutritionally balanced			
Convenience	23	32	13
A food that is easy to prepare			
A food that is ready to eat			
Function	9	7	11
A food that have some defined function			
Others	7	7	7
		χ^2 = 9.9 *	

* Significant difference ($p \leq 0.05$)

Highly significant differences were found between the associations of males and females. As shown in Table 2.3, women tended to associate more frequently functional foods with convenience, while

69% of men tended to associate functional foods with health and nutrient content related concepts more frequently.

No significant differences were found in consumers' descriptions of functional foods with age or educational qualification (c.f. Table 2.4).

Table 2.4. Percentage of consumers that gave descriptions of functional foods in each of the identified categories, by age and educational qualification.

Category	Percentage of consumers (%)					
	Age			Educational qualification		
	18 to 29 years	30 to 44 years	More than 45 years	Primary school	Secondary school	University degree
Health	37	41	33	30	37	43
Nutrient content	23	17	33	20	24	24
Convenience	20	14	27	30	21	24
Function	14	24	7	20	10	0
Others	6	4	0	0	8	9
	χ^2 = 7.3 [ns]			χ^2 = 4.9 [ns]		

[ns] No significant difference ($p>0.05$)

As Uruguayan consumers did not know what functional foods are, in order to evaluate if the concept of functional foods seemed to be attractive for them, they were asked if they believed that certain kinds of food could have a positive impact on their health. Ninety-nine percent of the participants answered that they believed in that statement, showing a positive attitude towards functional foods. Next, they were asked if they were interested in regularly buying and consuming that kind of foods, to which 98.5% of the participants answered yes. These results showed a surprisingly positive attitude towards the consumption of functional foods and might suggest that functional foods could reach an important market in Uruguay. This proportion of consumers interested in the consumption of functional foods is higher than that reported by Verbeke (2005; 2006) for Finish consumers. This author reported that approximately 80% of Finish consumers were interested in consuming functional foods that taste good. Moreover, Uruguayan consumers' interest in functional foods is also higher than that reported for French, American, and French Canadian consumers by Labrecque *et al.* (2006) and Herath *et al.* (2008) for Canadian consumers.

2.2.2.3. Preferred health claims

Participants were asked to indicate which health aspects or diseases they would prefer a food to have a positive influence on. As shown in Table 2.5, prevention of cancer had the highest priority, with 73.5% or the participants who mentioned this aspect. This proportion of consumers concerned about cancer is higher than that reported by Bech-Larsen *et al.* (2001) for Danish, Finish and American consumers, suggesting that Uruguayan consumers are more concerned about cancer. In Uruguay cancer is the second cause of death, comprising approximately 24% of the total deaths (MSP, 2003).

The differences between results from the present study and those from other countries could be attributed to cultural differences. This indicates the importance of performing local consumer studies in order to provide information to assess the industry in the development of functional foods.

Cardiovascular diseases and enhance the immune system were the second and third most mentioned aspects, with 53 and 50 % respectively. Therefore, the development of functional foods that address these aspects, and the use of health claims related to them could add to the acceptance of different food products. The most popular health claims for consumers seemed to be those that address relevant disease states, in agreement with van Kleef *et al.* (2005).

Table 2.5. Preferred areas of action of functional foods for the studied sample of Uruguayan consumers.

Health aspect or disease	Percentage of mentions (%)
Prevent cancer	73.5
Prevent cardiovascular diseases	53.0
Enhance the immune system	50.0
Lower cholesterol	30.5
Slimming effect	27.5
Increase healthy gut bacteria	24.0
Lower blood pressure	20.5
Prevent osteoporosis	18.5
Prevent anemia	17.0

Figures do not sum up to 100% as respondents were given the option of mentioning three possibilities.

These results are in agreement with those reported by Hilliam (1998), who mentioned that French and German consumers most often mention cardiovascular diseases, cancer, and the immune system as the preferred areas of action, probably due to the fact that in western countries there is a tendency towards a common consent about which diseases are the most important ones.

According to χ^2 test, highly significant differences ($p<0.001$) were found on the preferred areas of action of functional foods with the gender and age of the respondents. As shown in Table 2.6, a higher percentage of women than men mentioned increasing healthy gut bacteria and prevent osteoporosis as preferred areas of action. These results suggest that women seemed to be more concerned than men about health gut and osteoporosis, which probably is due to the fact that these health issues affect more frequently women than men. On the other hand, men were more concerned about cardiovascular diseases, lowering cholesterol and blood pressure.

Table 2.6. Preferred areas of action of functional foods for the studied sample of Uruguayan consumers, by gender and age.

Health aspect or disease	Percentage of mentions (%)				
	Gender		Age		
	Female	Male	18 to 29 years	30 to 44 years	More than 45 years
Prevent cancer	76.7	70.1	79.7	73.9	67.2
Prevent cardiovascular diseases	41.7	64.9	62.5	52.2	44.8
Enhance the immune system	50.5	49.5	54.7	50.7	44.8
Lower cholesterol	24.3	37.1	15.6	33.3	41.8
Slimming effect	28.2	26.8	35.9	23.2	23.9
Increase healthy gut bacteria	31.4	16.5	21.8	27.5	22.4
Lower blood pressure	16.5	24.7	9.4	17.4	34.3
Prevent osteoporosis	29.1	7.2	17.2	20.3	17.9
Prevent anemia	18.8	15.2	19.5	17.2	14.2

Figures do not sum up to 100% as respondents were given the option of mentioning three possibilities.

Besides, interest in preventing cardiovascular diseases seemed to lower with age, whereas interest in lowering cholesterol and blood pressure increased with age (c.f. Table 2.7). Young people seemed to be more interested in slimming effects than older people. Interest in reducing the risk of cancer type of health-related claim did not seem to vary with the age of the participants. In general, younger people tended to value disease preventing claims, while older people tended to give more importance to short term effects on health (e.g. preventing cardiovascular diseases vs. lowering cholesterol); in agreement with results reported by Bhaskaran & Hardley (2002).

The abovementioned differences in preferred health claims with gender and age have been reported by Stewart-Knox *et al*. (2007). According to these authors younger people, in particular females, seek for foods to control appetite and body weight, while older people are more interested in foods that lower their cholesterol and blood pressure. Moreover, de Jong *et al.* (2004) reported that older respondents were more often users of cholesterol-lowering spread than younger respondents.

Significant differences in preferred areas of action of functional foods were found with consumers' educational qualification, as shown in Table 2.7. More educated consumers tended to be more interested in functional foods that enhance their immune system, prevent osteoporosis, lower blood pressure and increase healthy gut bacteria. On the other hand, interest in functional foods that prevent cardiovascular diseases, lower cholesterol or have a slimming effect decreased as educational qualification increased. Educational qualification had no significant influence on consumers' interest in functional foods that prevent cancer and anemia; which were the most and least preferred areas of action of functional foods respectively, regardless of their educational qualification.

Table 2.7. Preferred areas of action of functional foods for the studied sample of Uruguayan consumers, by educational qualification.

Health aspect or disease	Percentage of mentions (%)		
	Primary school	Secondary school	University degree
Prevent cancer	71.4	75.0	70.6
Prevent cardiovascular diseases	61.9	53.9	47.1
Enhance the immune system	47.6	47.7	56.9
Lower cholesterol	38.1	26.6	25.5
Slimming effect	23.8	22.7	13.7
Increase healthy gut bacteria	14.3	33.6	29.4
Lower blood pressure	14.3	16.4	25.5
Prevent osteoporosis	14.3	23.4	25.5
Prevent anemia	18.3	17.0	14.8

Figures do not sum up to 100% as respondents were given the option of mentioning three possibilities.

The abovementioned results show that different health claims could be attractive to different market segments. This is in agreement with Stewart-Knox *et al.* (2007) who stated that the influence of socio-demographic variables could not be generalized and that it should be analyzed considering each specific type of functional food and health claim. Thus, consumer research is necessary to determine which health claims could be used according to which segment of the market the product is addressed to.

2.2.2.4. Consumer attitude towards labels

When asked the frequency in which they read different information on food's labels, 76% do not always read the list of ingredients on the label when purchasing a food product, whereas 79% stated that they do not always read nutritional information (Table 2.8). The healthiness of functional foods cannot be directly observed from a product; instead consumers need information-based knowledge on the nutrient content and possible health effect of a functional food. Therefore, as a large number of Uruguayan consumers would probably not read component or health claims on the labels, marketing and media campaigns would be essential in order to communicate a certain health claim.

Table 2.8. Frequency in which participants read different information on the labels of food products

Information	**Frequency**		
	Always	Sometimes	Never
Net weight	36.5%	48.5%	15.0%
Shelf life	77.0%	20.5%	2.5%
List of ingredients	24.0%	61.0%	15.0%
Nutritional information	21.0%	51.5%	27.5%
Country of origin	41.0%	43.0%	16.0%

2.2.3. PARTIAL CONCLUSIONS

Although the sample could not be considered representative of the general Uruguayan population, the present study provided a first insight into Uruguayan consumers' perception of functional foods.

A wholesome and varied diet was perceived as a decisive factor in consumers' mind in relation to maintaining their health, which suggests that Uruguayan consumers might have a positive attitude towards functional foods. The importance given to diet was higher for women and older people, suggesting that these groups might be more prone to accepting functional foods. Uruguayan consumers were not familiar with the term ‘functional food’. However, most of the participants were interested in consuming foods with a positive impact on their health. This suggests that functional foods could be an interesting niche market for Uruguayan food companies.

For the studied sample, cardiovascular diseases, cancer, and the immune system were the preferred areas of action of functional foods. Therefore, the development of functional foods enriched with fibre or antioxidants seems an interesting alternative to address consumers’ health interests. Considering Uruguayan consumers’ dietary pattern, the development of these types of products could also have a positive impact on the health status of the population.

Differences in preferred areas of action of functional foods were found with gender and age, suggesting that consumer perception of functional foods and health claims should be studied in the specific segment of the market the product is addressed to. For example, older people seemed more interested in functional foods that provided a short term benefit on their health, whereas younger consumers might be more interested in products which prevent diseases.

2.3. CONSUMERS' PERCEPTION OF REGULAR AND FUNCTIONAL YOGURTS

2.3.1. MATERIALS AND METHODS

2.3.1.1. Participants

The study was conducted in the city of Montevideo, Uruguay. Fifty people participated in the study; 42% of which were males and 58% female. Participants ranged in age from 18 to 81 years old (mean 33.5 years old, standard deviation 14.2 years old). Participants were randomly recruited at shopping areas, universities campus and public places. Participants were given the images shown in 2.3.1.2, an evaluation sheet and were asked to fill the questionnaire by themselves in the recruitment place. This was done in order to minimize the influence of the interviewer. Participants were asked to complete the word association and then the hard laddering task.

2.3.1.2. Stimuli

As stimuli a plain yogurt was selected due to its recognized healthy image. Five types of yogurts were considered: three types of conventional yogurts (regular plain yogurt, low-fat plain yogurt and low-calorie plain yogurt) and two types of functional yogurts (plain yogurt enriched with antioxidants, plain yogurt enriched with fibre). Functional ingredients were selected considering consumers' preferred areas of action of functional foods (c.f. section 2.2.2.3). The information was presented using a picture of a plain yogurt, as shown in Figure 2.3. Images were printed in glossy paper and coated with contact paper. The five images were presented to participants in random order, numbered with three-digit random codes.

Figure 2.1. Example of a functional yogurt image used in the study.

2.3.1.3. Word association

Participants were asked to evaluate the five images, one at a time, and to write down the first four images, associations, thoughts or feelings that came to their minds.

2.3.1.4. Hard Laddering

Respondents were asked to answer the question ‘If you were to choose to buy one of these yogurts, which one would you buy?’. Then, consumers were asked about the reasons for this choice using a series of why questions, as shown in Figure 2.2. After this, consumers were asked the same questions but this time for the yogurts they were less likely to buy.

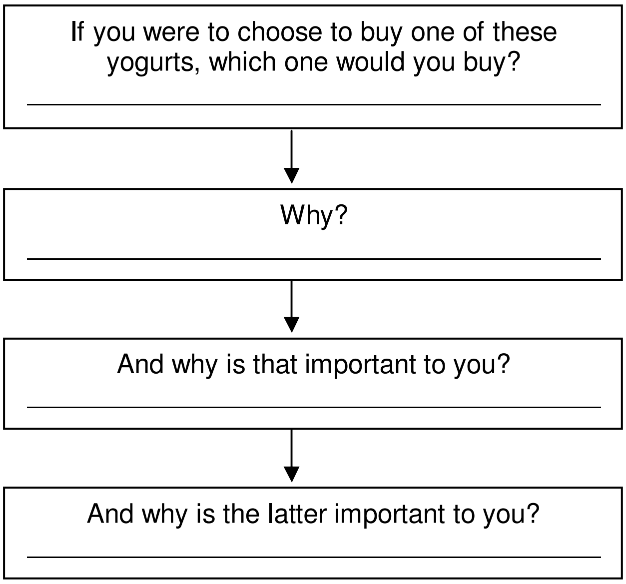


Figure 2.2. Example of the hard laddering chart to be filled in by respondents.

All participants took part in both tasks. Hard laddering was always carried out after word association. Word association was carried out first because it provided associations of the five evaluated products, generated by the individual assessment of the concepts that were already present in consumers' minds. After this, participants were asked to compare the products and to select one. Then, consumers were asked to elicit the more unconscious reasons that motivated their choices by performing the laddering task. The possibility of randomizing the tasks order was not considered in order to avoid comparisons between the products and the elicitation of unconscious terms before the free association task.

2.3.1.5. Attitudinal questionnaire

After completing both tasks, participants were asked to answer a questionnaire about their attitudes towards health and nutrition. Participants had to endorse their degree of agreement with 16 statements using a 9-box scale anchored with 'I completely disagree' on the left and 'I completely agree' on the right. The questionnaire is shown in Appendix D. The answers to this questionnaire served to identify groups of consumers that have different interests and concerns on health and nutrition.

The attitudinal questionnaire was developed by modifying and translating into Spanish some items from published work (Steptoe *et al.,* 1995; Roininen *et al.*, 1999) and by adding some new items (as those related to the products considered in the present study).

2.3.1.6. Data analysis

2.3.1.6.1. Word association

The elicited associations were qualitatively analysed. First, a search for recurrent terms within each yogurt concept was performed. Terms with similar meaning were grouped within each yogurt concept. This classification was performed independently by three researchers considering personal interpretation of the meaning of the words and word synonymy as determined by a Spanish dictionary. After individually evaluating the data, a meeting of the researchers was undertaken in order to check the agreement between their classifications. The final categories and their names were determined by consensus between the three researchers considering their three independent classifications and discussion between them. Categories mentioned by more than 10% of the consumers were considered. Frequencies in each category were determined by counting the number of consumers that used those words to describe the concept. Then, associations from the different yogurts were compared and merged. This task was carried out by the three researchers that performed the classification of terms. Frequencies of word counting in each category were calculated for each yogurt concept. Chi-square was calculated for evaluating differences in consumers' perception of the yogurts.

Correspondence analysis was applied in order to visualize the relationship between concepts and categories. Correspondence analysis is a descriptive/exploratory technique designed to analyze simple two-way contingency tables containing some measure of correspondence between the rows and columns. Using this technique row and column variables were spatially represented, which allowed a visual representation of the data (Greenacre, 1984; ten Kleij & Musters, 2003).

2.3.1.6.2. Hard Laddering

Data from the laddering task was analyzed as proposed by Reynolds & Gutman (1988). The content of each respondent's laddering task was analyzed. Attributes, consequences and values having the same meaning were grouped together and labeled. Hierarchical value maps (HVM) were constructed using

LadderMap software (Gengler & Thomas, 1993). The cut-off points used in the hierarchical value maps were chosen as 10 % of the size of the consumer sample (Reynolds & Gutman, 1988). This cut-off level means that when a link is considered between two concepts at least ten percent of the participants in the sample mentioned that direct or indirect link.

2.3.1.6.3. Attitudinal questionnaire

In order to identify groups of consumers with different concerns about health and nutritional issues, hierarchical cluster analysis was performed on data from attitudinal questionnaire. Euclidean distances and Ward's aggregation method were used.

An analysis of variance was performed on the attitudinal questionnaire ratings considering cluster as fixed source of variation. Honestly significant differences were calculated using Tukey's test. Differences were considered significant when $p \leq 0.05$.

Results for the word association and hard laddering task were analyzed, as previously described, separately for each cluster.

2.3.2. RESULTS

2.3.2.1. Word association

Table 2.9 shows the nineteen categories associated with each of the evaluated conventional and functional plain yogurts. Participants' associations of regular yogurt were mainly related to sensory characteristics, health and nutrition. The remaining associations of this product were related to fresh and natural.

Consumers' associations were highly significantly modified (χ^2 = 520.1, $p<0.001$) when nutritional modifications were introduced to the yogurts.

As shown in Table 2.9, participants associated low-fat or low-calorie plain yogurts with healthy products. However, the associations related to liking or sensory characteristics occurred in a lower frequency. This could be explained considering that participants associated these products with sensory defects, particularly flavour and texture defects. Besides, there were also an important number of associations related to diet or a slimming effect.

Moreover, associations related to yogurts enriched with fibre and antioxidants were mainly related to health, the positive effects of these ingredients on health and the prevention of diseases, which might be the reasons for consuming these products (c.f. Table 2.9). In the case of yogurt enriched with antioxidants participants also associated it with a product that will help them keeping themselves young or prevent aging. Other categories that came up were related to changes in flavour and texture due to the addition of functional ingredients to yogurt, which led to associations related to disliking and negative intention to purchase. Also, consumers perceived these products as interesting, suggesting that consumers might be prone to consuming this type of functional yogurts. In the case of yogurts enriched with fibre, some participants regarded them as a product aimed for a specific population or only for people with gastrointestinal disorders.

Table 2.9. Results of the word association task. Examples of individual associations, association categories and frequencies in which they occurred for the five evaluated yogurt concepts.

Category	Examples	Regular yogurt	Low-fat yogurt	Low-calorie yogurt	Yogurt enriched with antioxidants	Yogurt enriched with fibre
Healthy	Healthy, health	21	25	19	35	23
Nutritious	Nutritious, rich in nutrients	5	5	1	3	6
Prevention of diseases	Prevention of cancer, prevention of cardiovascular diseases	0	0	0	12	6
Positive impact on the organism	Lowers cholesterol, enhance gut health	0	5	0	0	24
Youth	Youth, keeping young, preventing aging	0	0	0	7	0
Diet	Diet, slimming effect	0	18	35	0	1
Light	Light	0	13	14	0	0
Sensory characteristics	Creamy, thick, soft, acid, sweet, white, neutral taste	32	19	11	9	13
Texture defects	Too fluid, gummy texture, syneresis, bad texture, gritty texture, rough	0	14	6	0	5

Table 2.9 (cont.). Results for the word association task. Examples of individual associations, association categories and frequencies in which they occurred for the five evaluated yogurt concepts.

Category	Examples	Regular yogurt	Low-fat yogurt	Low-calorie yogurt	Yogurt enriched with antioxidants	Yogurt enriched with fibre
Flavour defects	Disgusting taste, bad taste, bitter aftertaste, off-flavour	0	3	8	7	0
Sweeteners	Sweeteners	0	0	7	0	0
Liking	I like it, tasty, delicious	15	0	6	7	7
Disliking	I don't like it, disgusting	0	5	8	3	7
Intention to try	I would try it, I want to try it, I would to consume it	2	0	0	5	5
Negative intention to try	I would not try it, I would not consume it	0	3	8	3	4
Natural	Natural	8	2	0	0	6
Fresh	Fresh	5	2	2	0	0
Interesting	Interesting, novel	0	0	0	6	1
Aimed to a specific population	Aimed to a specific population, for people with gastrointestinal disorders	0	0	0	0	6

As mentioned in section 2.3.1.6.1, correspondence analysis was used to visualize the relationship between products and associations. The resulting perceptual map is shown in Figure 2.3. The first two dimensions of the correspondence analysis explained 73.0% of the variability of the experimental data. This map shows the abovementioned differences in consumers' perception of the evaluated yogurts. The evaluated yogurts were separated into three groups; one corresponding to regular yogurt, other comprised of low-fat and low-calorie yogurts and a last one composed of functional yogurts. These groups of products were associated with different categories which consisted of different attributes relevant for consumers and motivations for consuming them. This analysis showed that regular yogurt was associated with a natural, fresh product, having a group of sensory characteristics that were drivers of liking. On the other hand, low-calorie and low-fat yogurts were mainly associated with a slimming effect and with a group of sensory defects that were drivers of disliking and of negative intention to try. Meanwhile, associations of functional yogurts were related to health, interest, novelty and the possibility of disliking due to negative sensory changes caused by the incorporation of functional ingredients.

2.3.2.2. Hard laddering

During the hard laddering task each participants chose the yogurt they were most and least likely to buy among the five considered yogurts. The frequencies in which each yogurt was chosen as most and least likely to buy are shown in Figure 2.4.

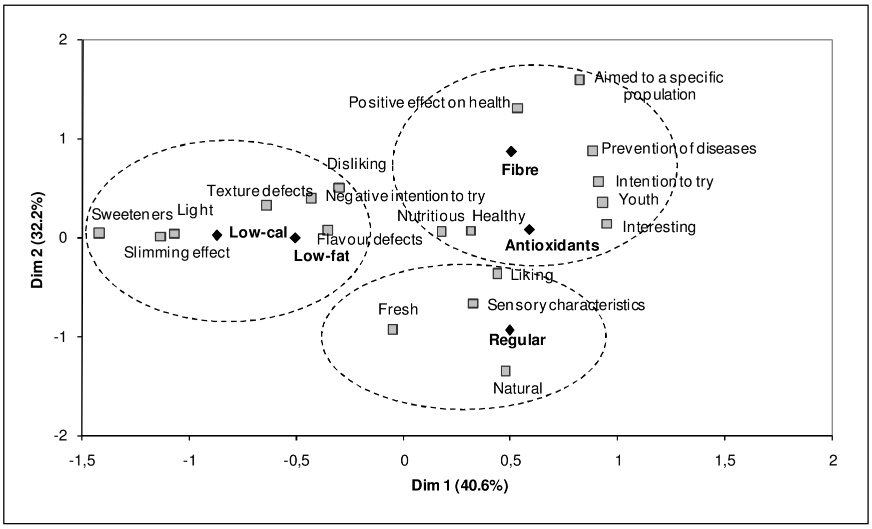


Figure 2.3. Correspondence analysis plot of categories associated with the five evaluated yogurt concepts during word association task for the whole consumer sample.

Yogurt enriched with antioxidants was the most preferred, followed by yogurt enriched with fibre and low-fat yogurt. On the other hand, regular yogurt and low-calorie yogurt were the least preferred. These results indicate that participants were interested in consuming functional yogurts, and that they were preferred over regular and low-cal yogurts.

Hierarchical value maps were used to understand reasons behind participants' choices. As shown in Figure 2.5, the identified means-end-chains were related to healthiness and pleasure. The attributes elicited during this task were mainly related to the attributes presented on the cards, which suggest that the first constructs in consumers' minds where the differences between the products.

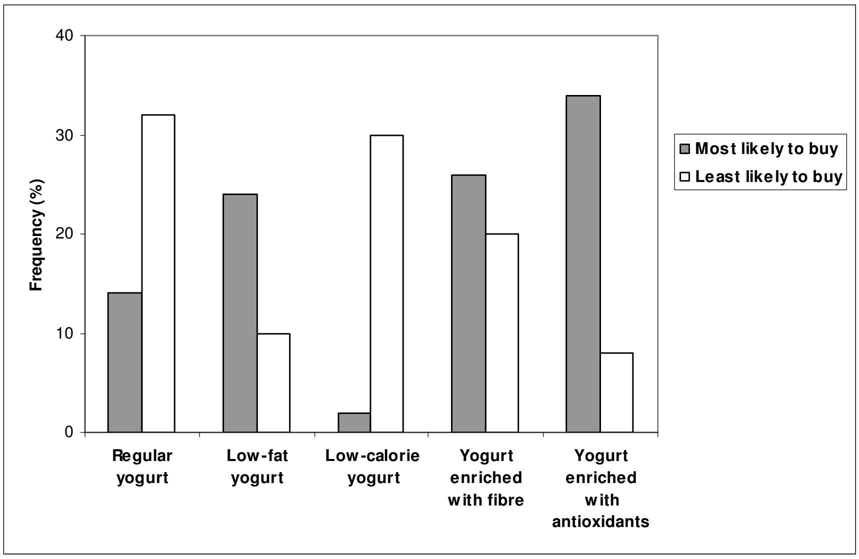


Figure 2.4. Frequencies in which each of the five yogurt concepts were chosen as most and least likely to buy by the whole consumer sample.

Reasons for choosing functional foods were related to health. Health-related reasons were mainly associated with prevention of disease, healthiness, well being, and live longer. Pleasure derived from consuming yogurts was one of the reasons for choosing regular and for not choosing low-calorie yogurt and low-fat yogurt.

2.3.2.3. Influence of attitude towards health and nutrition on consumers' perception of functional yogurts

Table 2.10 shows the results from the hierarchical cluster analysis, which identified two groups of consumers with different attitudes towards health and nutrition. Cluster 1 was composed of 20 participants and Cluster 2 composed of 30 participants. Although the number of participants might seem small, it could be considered adequate as the study deals with qualitative techniques.

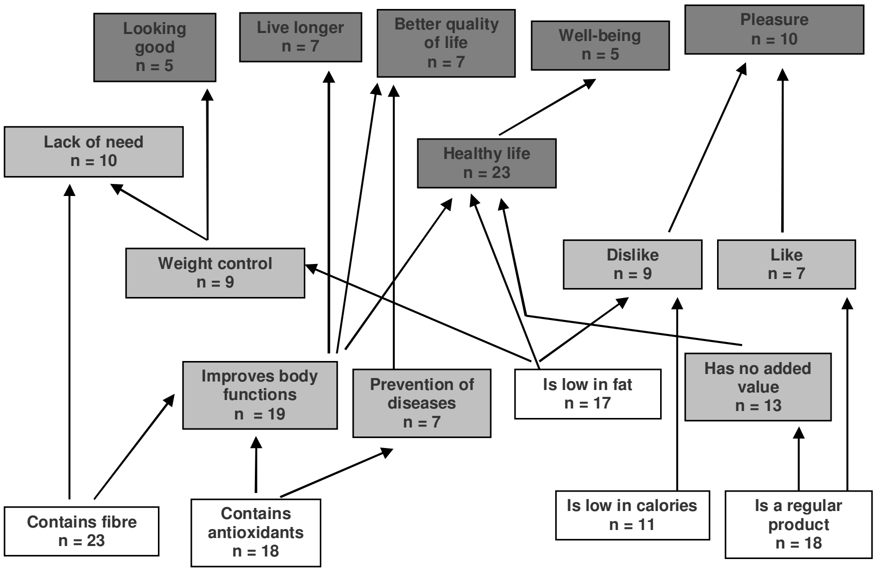


Figure 2.5. Hierarchical value map of hard laddering for the whole consumer sample (n=50, cut off = 5).

Highly significant differences were found between the clusters' ratings for 10 out of the 16 statements of the questionnaire, as shown in Table 2.10. Items 1-3 and 8-10 were related to the importance of diet and food on health. For these items no significant differences (p>0.05) were found between the ratings of the two identified clusters, suggesting that both agreed on the importance of diet. However, participants in Cluster 1 were more worried about maintaining their health (items 4-6), had a more balanced diet (items 11-12) and were more willing to consume healthy products (13-16) than those in Cluster 2 (Table 2.10). This higher interest in consuming healthy products was reflected in a higher willingness to compromise liking for healthiness (Table 2.10).

Table 2.10. Average scores for the items of the attitudinal questionnaire about health and nutrition for each of the two identified clusters.

Statements	**Average score**	
	Cluster 1 (n = 20)	Cluster 2 (n = 30)
1. Diet is important for my health	6.8 [a]	6.9 [a]
2. Consuming some food products could have a positive impact on my health	6.9 [a]	6.9 [a]
3. Consuming some food products could help preventing some diseases	6.7 [a]	6.6 [a]
4. I do all I can to keep myself healthy	6.0 [a]	4.5 [b]
5. I am willing to make sacrifices to keep myself healthy	6.2 [a]	4.5 [b]
6. I am interested in taking measures for preventing the occurrence of some diseases	6.5 [a]	5.8 [b]
7. I am interested in losing weight	4.7 [a]	2.9 [b]
8. High fat intake could increase the risk of some diseases	6.7 [a]	6.8 [a]
9. High fibre intake could decrease the risk of some diseases	6.2 [a]	6.1 [a]
10. Antioxidants intake could decrease the risk of some diseases	6.6 [a]	6.2 [a]
11. Healthiness and nutritional content have a high impact on my food choices	5.7 [a]	3.8 [b]
12. I always follow a healthy and balanced diet	6.0 [a]	4.5 [b]
13. I am willing to consume products that have a positive impact on my health	6.6 [a]	6 [b]
14. I am interested in consuming products that have a positive impact on my health even if I don’t like them as much as others	5.9 [a]	3.7 [b]
15. I am interested in consuming products with low-calorie content	5.8 [a]	3.2 [b]
16. I am interested in consuming products with low-fat content	6.4 [a]	4.0 [b]

Values with different superscripts within one row indicate that average scores for cluster 1 and cluster 2 are significantly different according to Tukey’s test ($p \leq 0.05$). Items were evaluated using 9-box scale varying from ‘I completely disagree’ to ‘I completely agree’.

Therefore, participants in Cluster 1 might be more interested in consuming functional products. Clusters significantly ($p<0.001$) differed in their gender and age distribution. Cluster 1 was mainly composed of women (74%) and showed the highest mean age (40.7 years); whereas Cluster 2 was composed of 52% men and 48% women, showing the lowest average age (30.2 years). This suggests that women and old participants were more conscious and interested in health and nutritional issues, in agreement with results from section 2.2.2.1 and published studies (Bogue & Ryan, 2000; Poulsen, 1999; de Jong *et al.*, 2003; Siró *et al.*, 2008). These authors stated that the most positive group towards the effects of diet on health and functional foods are women and middle-aged or elderly consumers. The question that arose from these results is if these two groups of participants perceived the evaluated functional yogurts in a different way, and if the evaluated qualitative techniques were able to detect these differences. In order to answer these questions word association and hard laddering tasks were analyzed separately for each cluster.

No significant differences were found between the associations of the clusters for regular yogurt (χ^2 = 1.69, p = 0.89), yogurt enriched with fibre (χ^2 = 9.51, p = 0.73) and yogurt enriched with antioxidants (χ^2 = 2.67, p = 0.99); suggesting that both clusters perceived these products similarly. On the other hand, participants in both clusters perceived low-fat and low-calorie yogurts significantly differently, as shown in Table 2.11.

Participants in Cluster 2 associated these products more frequently with sensory defects; products they dislike and they were not willing to try than participants in Cluster 1. This is in agreement with the fact that participants in Cluster 2 were less interested in consuming low fat and low-calorie products, and were less interested in compromising sensory characteristics for eventual health benefits (c.f. Table 2.10).

Table 2.11. Differences in the associations of both clusters for low-fat and low-calorie yogurt for both clusters.

Category	Low-fat yogurt		Low-calorie yogurt	
	Cluster 1	Cluster 2	Cluster 1	Cluster 2
Healthy	12	13	8	11
Nutritious	3	2	1	0
Positive impact on the organism	1	4	0	0
Diet	5	13	12	23
Light	7	6	8	6
Sensory characteristics	9	10	5	6
Texture defects	2	12	0	6
Flavour defects	0	3	0	8
Sweeteners	0	0	2	5
Liking	0	0	4	2
Disliking	0	5	0	8
Negative intention to try	0	3	0	8
Natural	0	2	0	0
Fresh	2	0	1	1
χ^2	20.50		19.84	
p	0.039		0.047	

Categories that were not mentioned for these products are not shown

Correspondence analysis was performed separately for each cluster and the resulting perceptual maps are shown in Figure 2.6. The first two dimensions of the correspondence analysis explained 71.2% and 66.8% of the variability of the experimental data for Cluster 1 and 2 respectively. These maps showed the previously mentioned differences between the clusters. For participants in Cluster 2, the evaluated yogurts were separated into three groups; one corresponding to regular yogurt, other comprised of low-fat and low-calorie yogurts and a last one composed of functional yogurts. Consumers in Cluster 2 associated low-calorie and low-fat yogurts with sensory defects that were drivers of disliking. Functional yogurts were related to health but also to the possibility of disliking due to negative sensory changes caused by the incorporation of functional ingredients.

On the other hand, as shown in Figure 2.6 b), low-fat and low-calorie yogurts were not associated with sensory defects or negative intention to try for participants in Cluster 1. Furthermore, yogurts enriched with fibre and antioxidants were sorted into different groups; being the former related to a product with a positive impact on health and the latter with the prevention of diseases and a positive intention to try. Consumers in this cluster also mentioned sensory defects when thinking of functional yogurts.

Differences in the associations of the clusters were related to their different attitudes towards health and nutrition.

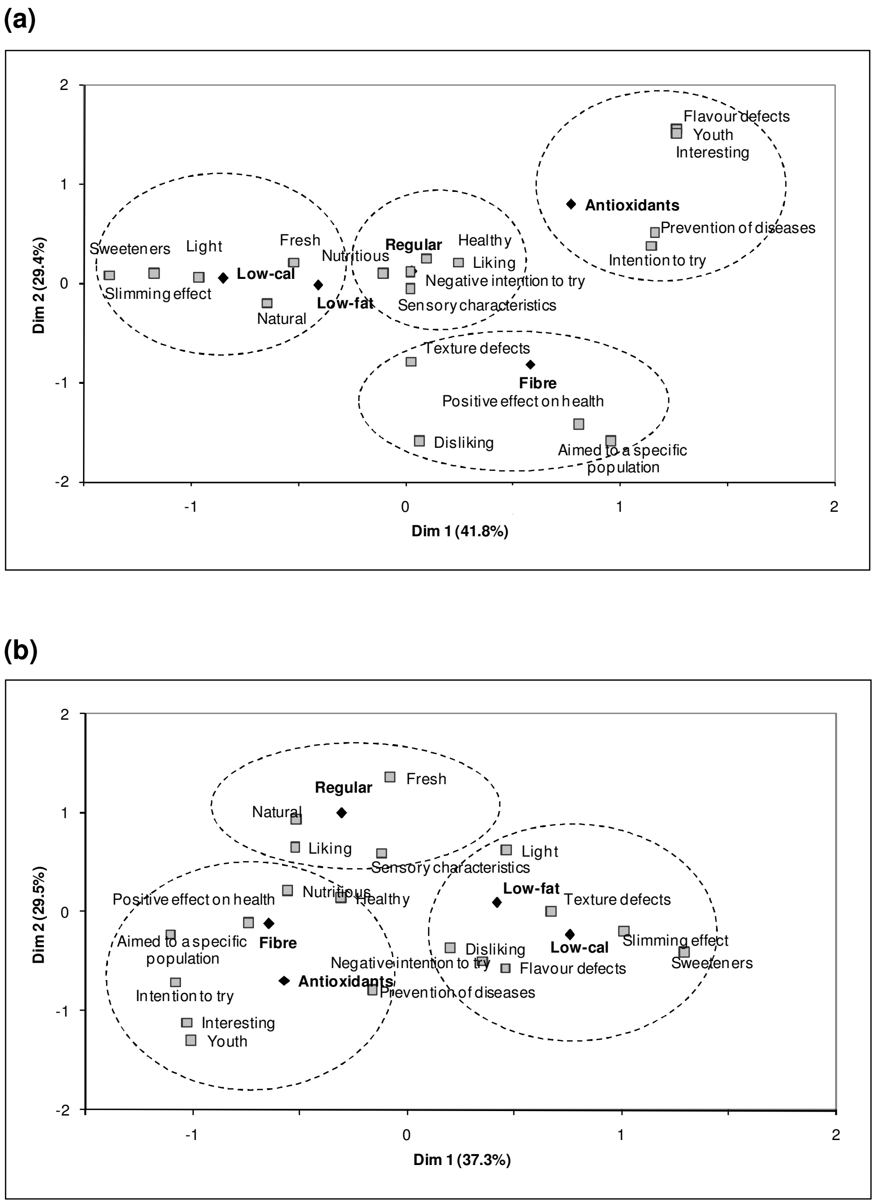


Figure 2.6. Correspondence analysis plot of categories associated with the five evaluated yogurt concepts during word association task for participants in **(a)** Cluster 1 and **(b)** Cluster 2.

As shown in Table 2.12, no differences were shown in the frequency in which participants chose the yogurts enriched with fibre and antioxidants as the product they were most and least likely to buy. This is in agreement with the fact that no significant differences were shown in the categories elicited in the word association task of these products.

Table 2.12. Frequencies in which each of the five yogurt concepts were chosen as most and least likely to buy by consumers in Cluster 1 and 2.

	Cluster	**Regular yogurt**	**Low-fat yogurt**	**Low-calorie yogurt**	**Yogurt enriched with antioxidants**	**Yogurt enriched with fibre**
Most likely to buy	1	5.0%	35.0%	0%	35.0%	25.0%
	2	20.0%	16.7%	3.3%	33.3%	26.7%
Least likely to buy	1	55.0%	10.0%	5.0%	5.0%	25.0%
	2	16.%	10.0%	46.7%	10.0%	16.7%

On the contrary, when considering the product they were most likely to buy, participants in Cluster 1 chose more frequently low-fat yogurt whereas participants in Cluster 2 chose more frequently regular yogurt. Besides, when considering the yogurt they were least likely to buy, low-calorie yogurt was the most frequently mentioned by participants in Cluster 2, while regular yogurt was the most mentioned by respondents in Cluster 1. This could be explained by the different attitudes expressed by members of the clusters towards health and nutrition and are in agreement with results from the word association task in which participants in

Cluster 2 associated low-fat and low-calorie with products they dislike.

Hierarchical value maps were used to understand reasons behind participants' choices. Cut-off points were considered as 10% of the size of each cluster and corresponded to 2 and 3 for Clusters 1 and 2 respectively. Some differences were found in the hierarchical maps of the clusters, as shown in Figures 2.7a and 2.7b. Pleasure was mentioned more frequently by consumers in Cluster 2 as a reason for choosing regular yogurt and for not choosing low-calorie yogurt, which is in agreement with the fact that participants gave greater importance to sensory characteristics of foods than Cluster 1.

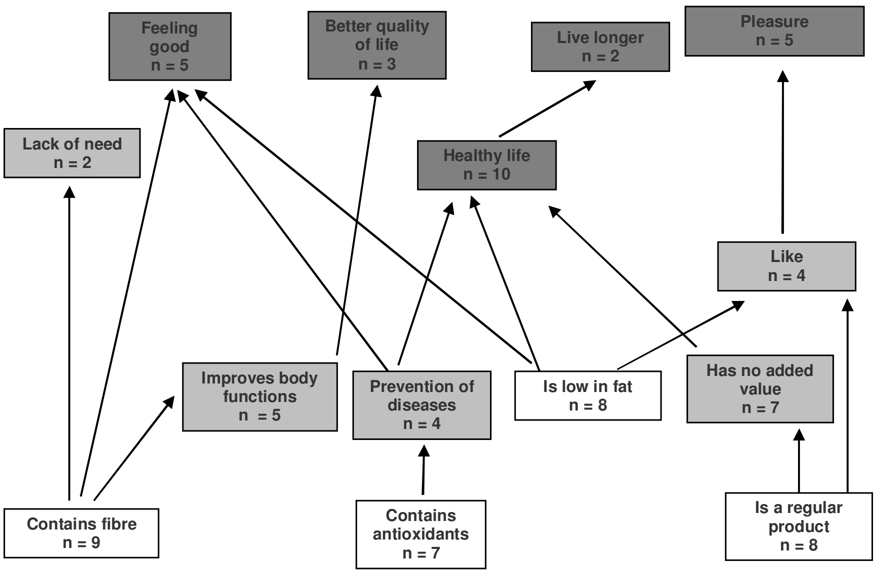


Figure 2.7 a). Hierarchical value map of hard laddering for consumers in Cluster 1 (n=20, cut off = 2).

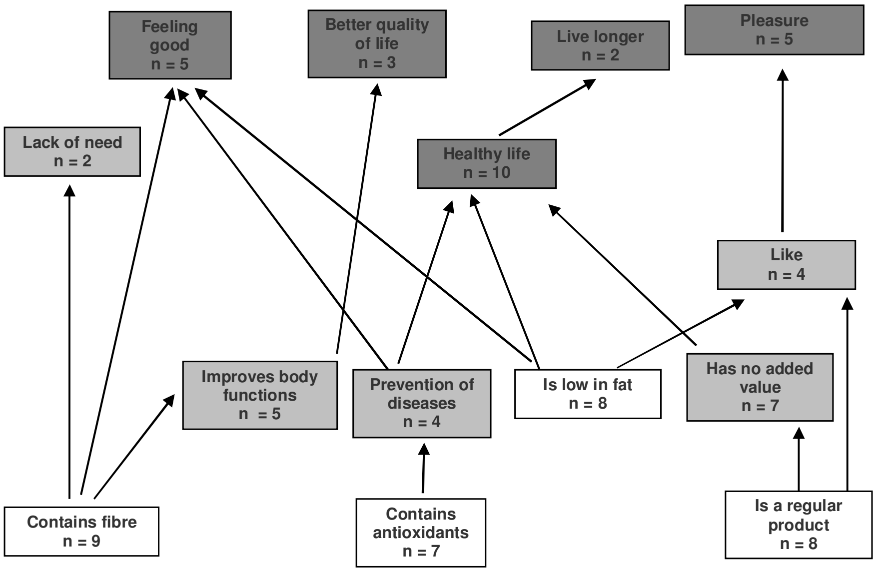


Figure 2.7 b). Hierarchical value map of hard laddering for participants in Cluster 2 (n=30, cut off = 3).

2.3.3. DISCUSSION

Word association provided an interest insight into consumers' perception of functional and conventional yogurts, which could be useful for product development and marketing. Results suggested that, apart from associating regular yogurt with a healthy product, consumers associated it with different sensory characteristics, mainly related to texture and flavour and to a product they like. This shows the importance of sensory attributes on consumers' perception and acceptance of yogurts. Consumers expect to find texture characteristics such as creamy, soft or thick, and flavour characteristics such as acid. This stresses the importance of these sensory attributes as consumers might be disappointed if they do not find them in a plain yogurt. Low-fat and low-calorie yogurts were mainly associated with diet or a slimming effect, indicating that it might be what motivates participants to consume these types of products. Besides, participants did not frequently associate them with products they would consume because of their sensory characteristics and the pleasure that consuming these products might cause them. This could be explained by another category that was associated with these types of products, which is that related to sensory defects. In the case of low-fat yogurts, texture defects were the most important sensory defects, which could explained by the influence of fat removal and the addition of hydrocolloids in the texture of yogurt. Flavour defects, particularly those associated with the use of sweeteners and bitter aftertaste, were the most common in the case of low-calorie yogurt. These associations could be related to common sensory defects of low-fat and low-calorie yogurts in Uruguayan marketplace. Associations related to yogurts enriched with fibre and antioxidants were mainly related to health, the positive effects of these ingredients on health and the prevention of diseases, which might be the reasons for consuming these products. In the case of these products, consumers' perception might be useful for new product development, since they are not present in Uruguayan market.

Results from hard laddering and word association indicated that health and pleasure were the most important factors behind consumers' choice. According to results from Chapter 1, health and sensory characteristics were the most important factors for food choice for Uruguayan consumers. These factors were also the most important for determining the choice of functional yogurts. These results are similar to those reported by Urala & Lähteenmäki (2003). However, apart from health and pleasure, these authors reported that convenience and price were reasons for choosing functional foods. These factors were not mentioned in the present study, which could be related to the fact that these types of functional products are not present in Uruguayan market.

One of the reasons for not choosing regular yogurt was that it was not perceived as having an added value. This indicates consumers' interest in consuming products with a positive influence on their health, in agreement with results about functional foods perception of Uruguayan consumers (c.f. Section 3.2). On the other hand, sensory characteristics such as flavour and texture were mentioned as the main reason for not consuming low-fat and low-calorie yogurts, suggesting that consumers might not be willing to compromise taste to health, in agreement with Gilbert (2000), Augustin (2001), Tuorila & Cardello (2002), Cox *et al.* (2004) and Verbeke (2006).

There were some differences in the information provided by word association and hard laddering. Word association elicited concepts related to terms that might be conscious reasons for choosing or rejecting a product, and included affective, evaluative and cognitive constructs. On the other hand, hard laddering provided a small number of attributes as those elicited during this task were mainly related to the attributes presented on the cards. This suggests that the first constructs in consumer minds where the differences between the products. Besides, this methodology elicited mainly cognitive and evaluative constructs but was not able to yield affective ones.

Hard laddering was able to identify the values relevant for consumers and the links between them and product attributes. Although word association was not able to identify links, it was useful for identifying more attributes relevant for consumers that did not appear in the hard laddering task. This could be related to the fact that consumers are asked to individually assess the concepts in the case of word association, whereas they are asked to elicit reasons for choice in hard laddering.

Both techniques identified differences between the clusters with different attitudes towards health and nutrition. However, these differences were more easily identified with word association. Although some differences were found in the hierarchical maps of the clusters (Fig. 2.7a and Fig. 2.7b), these differences were more obvious in the perceptual map obtained from the word association task.

2.3.4. PARTIAL CONCLUSIONS

Word association and hard laddering were useful for evaluating consumers' perception of functional yogurts. According to both methodologies, health and pleasure were the most important factors related to consumers' perception of the products and behind consumers' choice. Health was the most important reason for choosing functional yogurts over conventional ones.

Results suggested that word association was an easy and quick methodology for gathering useful information about consumers' perception of a food product during new food product development. This methodology might allow identifying attributes that are relevant for consumer's acceptance of a product, common defects of products in the marketplace, motives behind consumers' choice and attributes that might limit consumers' interest in the product.

Word association allowed the elicitation of more attributes relevant for consumers than hard laddering. Using this technique some consequences related to product attributes were also identified. On the other hand, hard laddering allowed the identification of more consequences and values related to product attributes, and the links between them, which could be useful for understanding consumers' choices. Besides, hard laddering and word association were useful for studying differences between two groups of consumers with different attitude towards health and nutrition. However, word association was more sensitive in determining differences between these groups of consumers.

One of the main limitations of the present work is the fact that the same consumers participated in both methodologies, which might have affected the results. This issue needs to be addressed in future studies. Further research is needed to evaluate the applicability of word association to more complex choice situations.

2.4. CONCLUSIONS

Results from the present chapter confirmed Uruguayan consumers' interest in consuming functional foods. Most of the consumers that participated in the study stated that they were willing to consume food products with a positive impact on their health, particularly those that could reduce the risk of cardiovascular diseases or cancer and that enhance their immune system. Thus, when developing functional foods food companies should try to address these interests and select functional ingredients that could lead to the abovementioned health benefits. Considering these results, antioxidants and fibre could be interesting functional ingredients, in agreement with results from Chapter 1.

Consumers' perception of functional yogurts was mainly related to their effects on health. This suggests that healthiness perception of functional foods might play an important role in determining consumers' willingness to consume this type of products. However, sensory characteristics were also mentioned, suggesting that consumers might not be willing to consume functional products they do not like. Consumers want to consume food products with the usual sensory characteristics but with an added positive effect on their health.

CHAPTER 3

FACTORS AFFECTING CONSUMERS' PERCEPTION OF FUNCTIONAL FOODS

ABSTRACT

Conjoint analysis was used to study the influence of different factors on consumers' perception of functional foods. Consumers' perceived healthiness and willingness to try were significantly affected by the carrier product and the functional ingredient considered. Functional foods based on carrier products that were perceived healthy per se were more accepted by consumers than those based on 'unhealthy' products. The addition of functional ingredients to products with an intermediate healthy image led to the largest increase in consumers' willingness to consume when compared to their conventional counterparts. Nutritional knowledge had an important effect on consumers' willingness to consume functional foods. Whereas consumers with the lowest nutritional knowledge were not interested in consuming functional foods, the addition of fibre or antioxidants to healthy products increased the willingness to try the evaluated functional foods for consumers with the highest level of nutritional knowledge. Thus, lack of nutritional knowledge might hinder the acceptance of functional foods and thus the use of health claims might be necessary to assure that consumers are aware of their health benefits. Consumers increased their willingness to try functional milk desserts enriched with fibre and antioxidants when health claims were used. No differences were found between 'enhanced function' and 'reduced disease risk' claims, suggesting that both types of claims would be attractive for consumers. The way in which functional ingredients were declared affected consumers' perception of functional milk desserts. Consumers preferred functional foods in which the functional ingredients were declared using familiar names. The use

of compounds or scientific names had a negative impact on consumers' interest in functional fodos. If the use of a novel ingredient needs to be emphasized, its addition could be declared using its scientific name but incorporating a health claim on the label, in order to achieve a positive association in consumers' mind between the ingredient and its health effect. Furthermore, scores for expected liking decreased when information about the source of fibre or antioxidants was incorporated, which could be explained considering that when consumers knew the source of the functional ingredient they imagine the flavour of the source in the milk dessert concept. This decrease in expected liking led to a decrease in consumer willingness to purchase, showing the importance of hedonic expectations on the acceptance of functional foods.

3.1. INTRODUCTION

As discussed in Chapter 2, Uruguayan consumers seemed interested in consuming foods that have a positive influence on their health. However, there are several factors that might affect consumers' perception of functional foods and therefore might determine their willingness to consume them.

The acceptance of functional foods depends on the product that serves as carrier for the functional ingredient and the functional ingredient itself (Jonas & Beckmann, 1998; Poulsen, 1999; van Kleef *et al.*, 2005). Despite this, there is little research about which combinations of functinal ingredients and food carriers are most appealing to consumers (van Kleef *et al.*, 2005). For this reason, research is necessary to gather information about this issue.

Previous research showed that the evaluation of health claims is partly determined by the healthiness perception of the carrier product, which would suggest that certain health claims combine better with some food products (Bech-Larsen & Grunert, 2003; Roe *et al.*, 1999). However, results are quite contradictory. Some authors suggest that consumers find enrichment of 'non healthy' foods more justified than enrichment of foods which are perceived as healthy per se (Bech-Larsen & Grunert, 2003). On the other hand, other authors (Balasubramanian & Cole, 2002; van Kleef *et al.*, 2005) have found that consumers see products that are intrinsically healthy as more credible carriers of functional messages. van Kleef *et al.* (2005) explored carrier product and health claim compatibility for 100 hypothetical products. In their study they did not find a significant interaction between health claim and carrier. This result implies considerable flexibility in the design of functional foods, since the attractiveness of the health claim is not affected by the carrier.

Regarding which functional ingredients might be more appropriate for each carrier product, Poulsen (1999) reported that consumers showed a more positive attitude when the functional ingredient is inherent in the original product. Overall, research evidence is limited and inconsistent and what is available is based on some claim-product combinations only (van Kleef *et al.*, 2002).

Considering the importance of healthiness perception on consumers' interest in functional foods, lack of knowledge about the benefits related to the consumption of a functional ingredient could discourage the consumption of functional foods. Wansink *et al.* (2005) reported that the level of nutritional knowledge about soy was related to how much soy was consumed. Information about the relationship of nutritional knowledge and functional foods acceptance could be useful to functional food manufacturers as it might provide valuable information about how to communicate the health effects reliably to consumers (Oude Ophuis & van Trijp, 1995; Jonas & Beckmann, 1998; Poulsen, 1999; Nicolay, 2003; Vieira, 2003).

Considering that consumers' knowledge about the health effects of functional ingredients is many times limited, health claims are necessary to assure that consumers are aware of the health benefits of a functional food (van Kleef *et al.*, 2005). The extent to which consumers find health claims appealing depends on a number of factors, including the content and format of the message (Mazis & Raymond, 1997). In this context, research is needed to study how the format of health claims influence consumers' interest in functional foods.

A strategy for developing new functional food products is including new functional ingredients, which raised the question of how to declare their addition in functional foods. One example is the addition of fibre. Several products have been developed with the addition of different kinds of fibre (inulin, glucans, polydextrose, resistant starch, etc.). Food companies could declare fibre enrichment using its common name (i.e. fibre), focusing on the effects of a food component familiar to consumers, or the name of the compound or its scientific name, stressing the novelty of the ingredient. Little research has been performed on the influence of how ingredients are named on consumers' healthiness perception and their willingness to try of functional foods.

Functional ingredients could also be declared in functional foods specifying their source. However, including information about the source of functional ingredients could emphasize their novelty, and relate them to familiar products; which could make the product more attractive to consumers. However, consumers' perception of functional foods might change as they could link the food product with the source of the functional ingredient. This association could affect their perceived healthiness but also their liking. Several authors have reported that consumers are hardly willing to compromise on the taste of functional foods for eventual health benefits (Drewnowski & Gómez-Carneros, 2000; Augustin, 2003; Verbeke, 2006); being taste expectations a critical factor when selecting functional foods (Childs, 1997; Gilbert, 2000; Tuorila & Cardello, 2002; Nicolay, 2003). In order to assure the success in the market of new functional food products, the effect of information on consumers taste expectations needs to be studied.

The aim of the present chapter was to study the influence of different factors on consumers' perception of functional foods. In particular, the objectives of this chapter were to study: **(a)** the effect of different carriers and different functional ingredients on the perceived healthiness and willingness to try functional foods, **(b)** the influence of nutritional knowledge on perceived healthiness and willingness to try functional foods, **(c)** the influence of the name of the functional ingredient (common versus scientific name) and type of health claim on consumers' perceived healthiness and willingness to try a functional milk dessert, and **(d)** study the influence of information about the source of two functional ingredients, antioxidants and fibre, on consumers' perception of functional milk dessert concepts.

3.2. INFLUENCE OF CARRIERS, FUNCTIONAL INGREDIENTS AND NUTRITIONAL KNOWLEDGE ON CONSUMERS' PERCEIVED HEALTHINESS AND WILLINGNESS TO TRY FUNCTIONAL FOODS

3.2.1. MATERIALS AND METHODS

3.2.1.1. Participants

The study was conducted in the city of Montevideo, Uruguay. One hundred and four people participated in the study; 46% of which were males and 54% female. Participants ranged in age from 18 to 81 years old (mean 34.3 years old, standard deviation 14.5 years old). Participants were randomly recruited at shopping areas, universities and public places. Participants were given the questionnaire and were asked to fill it in by themselves in order to minimize the influence of the interviewer.

3.2.1.2. Conjoint task

Different functional foods were defined as concepts consisting of two dimensions: carriers and nutritional modifications of the carrier. The carriers corresponded to four different food products popular in Uruguay that might have different healthy image. The selected products were yogurt, milk desserts, pan bread, and mayonnaise. The considered nutritional modifications were: regular product, low-fat, enriched with antioxidants, and enriched with fibre. Therefore, for each carrier, consumers evaluated two regular and two functional products.

The concepts were created following a full factorial experimental design (4*4), resulting in a set of 16 food concepts. In each questionnaire, concepts were presented following a unique randomized balanced order, which further eliminated the possibility of order effects.

The 16 functional food concepts were presented to participants, who were asked to score the perceived healthiness of the different concepts, using a 7-box scale labeled on the left with ‘not at all healthy’ and on the right with ‘very healthy’, and to score their willingness to try them using a 7-point scale labeled on the left with ‘I would definitely not try it’, on the middle with ‘Maybe yes, maybe not’ and on the right with ‘I would definitely try it’.

3.2.1.3. Nutritional knowledge questionnaire

Nutritional knowledge was assessed using a modified version of the Nutrition Knowledge Questionnaire developed by Parmenter & Wardle (1999). The questionnaire was modified by removing some items, adding others and changing most of the products in the questionnaire in order to include foods that are commonly consumed in Uruguay. Some items of the original questionnaire were removed in order to reduce the time required for completing it, being the section related to everyday food choices completely removed. Items related to antioxidants were included to evaluate the influence of knowledge related to these compounds in the acceptance of functional foods enriched with them.

The questionnaire was composed of twenty-eight questions, and included one-hundred items divided in four sections: (i) experts' recommendations regarding healthy eating (10 items), (ii) knowledge about the nutrient content of different foods (54 items), (iii) knowledge about antioxidants (15 items), and (iv) knowledge about links between diet and diseases (21 items). The questionnaire is shown in Appendix E.

When analyzing participants' responses, one point was assigned to each item when the answer was correct. Scores were calculated for each of the four sections as well as a total nutrition knowledge score.

3.2.1.4. Data analysis

3.2.1.4.1. Conjoint analysis

Analysis of variance (ANOVA) was performed on data from perceived healthiness and willingness to try of different concepts. The following model was used:

Y = mean + main effect for consumer + main effects for conjoint variables (carrier and nutritional modification) + interactions among conjoint variables + random error

When the effects were significant, honestly significant differences were calculated using Tukey's test. Differences were considered significant when $p \leq 0.05$.

3.2.1.4.2. Cluster analysis

In order to identify groups of consumers who had different degree of nutritional knowledge, a hierarchical cluster analysis was performed on the scores from the four sections of the nutritional knowledge questionnaire. Euclidean distances and Ward's aggregation method were considered.

Gender and age differences between identified clusters were evaluated using the χ^2 statistical test.

In order to evaluate differences between the clusters' perception of the evaluated functional food concepts, the following ANOVA model was used:

Y = mean + main effects for conjoint variables + main effect for cluster + interactions among conjoint variables + interactions among conjoint variables and cluster + random error

The main effects those of the conjoint design (carrier and nutritional modification) and the cluster effect. All interactions among conjoint and cluster variables were considered.

When the effects were significant, honestly significant differences were calculated using Tukey's test. Differences were considered significant when $p \leq 0.05$.

All statistical analyses were performed using GenStat for Windows Discovery Edition 2 (VSN International, Hemel Hempstead, UK).

3.2.2. RESULTS

3.2.2.1. Conjoint analysis

Average scores for perceived healthiness and willingness to try for the evaluated concepts are shown in Table 3.1. Highly significant differences ($p<0.0001$) were found in the perceived healthiness and willingness to try the evaluated regular and functional food concepts, suggesting that consumers perceived them differently.

As shown in Table 3.1, regular yogurt was perceived as the healthiest carrier product, suggesting that consumers consider it as inherently healthy. This could be attributed to the fact that in Uruguay there is marketing activity to increase the healthy image of yogurt and functional yogurts are available in the market. On the other hand, mayonnaise showed the lowest scores for perceived healthiness, suggesting that consumers regard it as an unhealthy product. Milk desserts and pan bread showed perceived healthiness scores that corresponded to products with an intermediate healthy image.

Table 3.1. Average perceived healthiness and willingness to try scores for the evaluated regular and functional food concepts.

Concept	**Perceived healthiness**[§]	**Willingness to try**[§]
Yogurt	6.3 [h]	6.1 [e]
Low-fat yogurt	6.3 [h]	5.6 [d]
Yogurt enriched with fibre	6.3 [h]	5.8 [d,e]
Yogurt enriched with antioxidants	6.2 [h]	5.7 [d]
Milk dessert	4.9 [e]	5.6 [d]
Low-fat milk dessert	5.6 [g]	5.6 [d]
Milk dessert enriched with fibre	5.6 [g]	5.7 [d]
Milk dessert enriched with antioxidants	5.6 [g]	5.7 [d]
Pan bread	4.1 [d]	5.6 [d]
Low-fat pan bread	5.0 [e,f]	5.2 [b,c]
Pan bread enriched with fibre	5.2 [f]	5.4 [c,d]
Pan bread enriched with antioxidants	4.9 [e,f]	5.2 [b,c]
Mayonnaise	2.2 [a]	5.0 [b]
Low-fat mayonnaise	4.3 [d]	5.0 [b]
Mayonnaise enriched with fibre	3.4 [b]	4.1 [a]
Mayonnaise enriched with antioxidants	3.8 [c]	4.4 [a]

Mean values sharing the same letter within a column are not significantly different according to Tukey's test ($p>0.05$). [§] evaluated in 7-box scales

As shown in Table 3.2, ANOVA revealed that the main effect of the conjoint variables carrier and nutritional modification had a highly significant effect on perceived healthiness and willingness to try scores. Therefore, both variables depended on both the carrier product and the nutritional modification introduced to it.

Table 3.2. p-values for fixed effects tested in the ANOVA for healthiness and willingness to try scores.

Effect	***Healthiness***	***Willingness to try***
Consumer	<0.0001*	<0.0001*
Carrier	<0.0001*	<0.0001*
Nutritional modification	<0.0001*	0.0006*
Carrier * Nutritional modification	<0.0001*	0.0005*

* significant effect ($p\leq 0.05$)

Average scores for the main effects carrier product and nutritional modification are shown in Table 3.3. Yogurt and milk dessert showed the highest average scores for perceived healthiness and willingness to try.

Regarding the evaluated nutritional modifications, they caused an average significant increase in perceived healthiness. However, a decrease in willingness to try was registered. This suggests that consumers were more interested in regular products compared to their functional counterparts, despite the fact that they considered the former as less healthy.

Table 3.3. Average scores for the main effects of the ANOVA of healthiness and willingness to try scores.

	Average scores	
	Healthiness	**Willingness to try**
Carrier product		
Yogurt	6.3 [d]	5.8 [c]
Milk dessert	5.4 [c]	5.6 [c]
Pan bread	4.8 [b]	5.4 [b]
Mayonnaise	3.4 [a]	4.6 [a]
Nutritional modification		
None	4.4 [a]	5.6 [b]
Low-fat	5.3 [c]	5.4 [a]
Enriched with fibre	5.1 [b]	5.2 [a]
Enriched with antioxidants	5.2 [b]	5.2 [a]

Mean values sharing the same letter within a column and category are not significantly different (p>0.05)

As shown in Table 3.3, carrier main effect on perceived healthiness and willingness to try were larger than those for nutritional modifications, suggesting that carrier products had the largest effect on consumers' perception of healthiness of the evaluated foods concepts. Consumers' perceived healthiness was more dependent on the carrier products than on the functional ingredient added to them.

Furthermore, the interaction among carrier and nutritional modification was highly significant ($p<0.0001$) for both perceived healthiness and willingness to try (c.f. Table 3.2); indicating that certain combinations of carriers and nutritional modifications were evaluated as more/less healthy than would be expected from their separate evaluations.

The influence of nutritional modifications on perceived healthiness depended on the carrier product being considered. For yogurt, none of the evaluated nutritional modifications caused a significant increase in its perceived healthiness. On the other hand, all the evaluated nutritional modifications caused an increase in healthiness when the other three carrier products were considered.

3.2.2.2. Nutritional knowledge

As shown in Table 3.4, on average participants showed a low level of nutritional knowledge as they were able to answer correctly only 59.9% of the items. The average level of nutritional knowledge of the population under study was a little lower than that reported in European studies by Parmenter & Wardle (1999), Wardle *et al.* (2000) and McPherson & Dunkeld Turnbull (2000).

The level of nutritional knowledge for the sections 'experts' recommendations regarding healthy eating', 'knowledge about the nutrient content of different foods' and 'knowledge about links between diet and diseases' was similar. Consumers responded correctly approximately 60% of the questions of each of the sections of the questionnaire.

Table 3.4. Mean scores of the nutritional questionnaire for the whole consumer sample in the Nutritional Knowledge Questionnaire.

Nutritional Knowledge questionnaire item (maximum score)	Mean score for the whole consumer sample (n=104)
Experts' recommendations regarding healthy eating (10)	5.8
Nutrient content of different foods (54)	33.8
Antioxidants (15)	6.4
Links between diet and diseases (21)	14.9
Total (100)	59.9

Some areas of knowledge were found to be extremely poor. Participants showed little awareness of expert's nutritional guidelines as they answered correctly 58% of this section's items. Only 60% of the respondents were aware of the recommendations to reduce the intake of salt, fat and sugar, to cut down the intake of saturated fats or to increase the consumption of fibre. Although 72% of the participants indicated that it is recommended to increase the intake of fruits of vegetables, only 23 % of them were aware of the recommendation of eating at least five portions of fruits and vegetables a day. Besides, 60% of the participants thought that consuming less than three portions was adequate. This lack of awareness of the recommendations could be related to the low intake of fruits and vegetables reported in Section 1.2.

Knowledge related to nutrient content of foods was also strikingly low. Only 46% of the respondents knew that fat provides the most calories per gram, compared with 36% who thought that sugar was the highest calorie food. This confusion could be related to the fact that most low-sugar products stress the fact that they are low-calories, whereas when fat is reduced the stress is on fat rather than on calories. A large number of people failed to realize that there are foods that contain fat but no cholesterol (60%); that margarine and butter contain the same amount of fat (50%); or that whole and skimmed milk had the same amount of proteins (51%). Besides, although 87 % of the respondents were able to classify food products as high or low in salt, only 55% were able to do so with fibre content. For example, only 52% or the respondents indicated that red meat as low in fibre, which indicates a very low knowledge about this nutrient, suggesting that the population needs to be informed about fibre.

Knowledge related to the links between diet and diseases was also low. Almost all participants (90%) were aware of the relationship between fat intake, obesity and cardiovascular diseases. However, 40 and 48% of the respondents did not know of any diseases or health problems related to low intake of fruits, vegetables and fibre. Besides, 48% of respondents did not know of any diseases or health problems related to low fibre intake.

Also, as shown in Table 3.4, participants were not familiar with antioxidants as they answered correctly only 42.6% of the items of this section. This low level of nutritional knowledge could limit consumers' interest in consuming functional foods, as consumers might not be aware of the health benefits of some functional ingredients.

Using hierarchical cluster analysis, three clusters of participants were identified, showing different level of nutritional knowledge; Cluster 1 composed of 45 participants, Cluster 2 composed of 26 and Cluster 3 composed of 33. Highly significant differences were found between clusters' scores for the four sections of the nutritional knowledge questionnaire, as shown in Table 3.5.

While participants in Cluster 1 showed the highest level of nutritional knowledge, participants in Cluster 2 showed the lowest as they answered correctly only 39.6% of the questionnaire, and participants in Cluster 3 showed an intermediate level of nutritional knowledge. No significant differences were found in the gender and age distribution of the clusters (c.f. Table 3.6), suggesting that these factors were not the cause of the differences in their nutritional knowledge. The question that arose from these results was if these three groups of consumers perceived functional foods in a different way.

Table 3.5. Mean scores of the Nutritional Knowledge Questionnaire sections for the three identified clusters.

Nutritional Knowledge questionnaire item (maximum score)	Mean score		
	Cluster 1 (n = 45)	Cluster 2 (n = 26)	Cluster 3 (n=33)
Experts' recommendations regarding healthy eating (10)	6.0 [a]	5.3 [b]	6.0 [a]
Nutrient content of different foods (54)	41.4 [a]	23.3 [c]	31.6 [b]
Antioxidants (15)	9.0 [a]	2.2 [c]	6.2 [b]
Links between diet and diseases (21)	16.1 [a]	8.8 [c]	14.8 [b]
Total (100)	72.6 [a]	39.6 [c]	58.6 [b]

Values for the clusters with different superscripts within one row indicate that average scores are significantly different according to Tukey's test ($p \leq 0.05$)

Table 3.6. Gender and age distribution of the three identified clusters in the Nutritional Knowledge Questionnaire.

	Percentage of consumers		
	Cluster 1 (n = 45)	**Cluster 2 (n = 26)**	**Cluster 3 (n=33)**
Gender			
Men	44%	42%	51%
Women	56%	58%	49%
		$\chi^2 = 0.59$ ns	
Age			
18 to 34 years	69%	61%	58%
More than 34 years	31%	39%	42%
		$\chi^2 = 1.11$ ns	

ns – Not significant difference (p>0.05)

3.2.2.3. Influence of nutritional knowledge on consumers' perception of functional foods

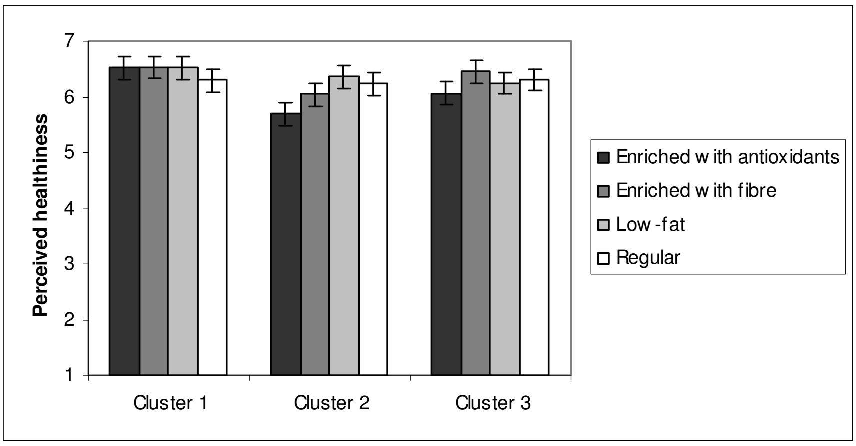
Highly significant differences were found in the healthiness scores of the clusters ($p<0.0001$), suggesting that nutritional knowledge significantly affected healthiness perception of the selected functional food products.

Perceived healthiness scores were significantly affected by the interactions cluster*carrier ($p=0.009$) and cluster*nutritional modification ($p=0.02$), suggesting that differences in healthiness perception between the clusters depended on the carrier product and the nutritional modification introduced.

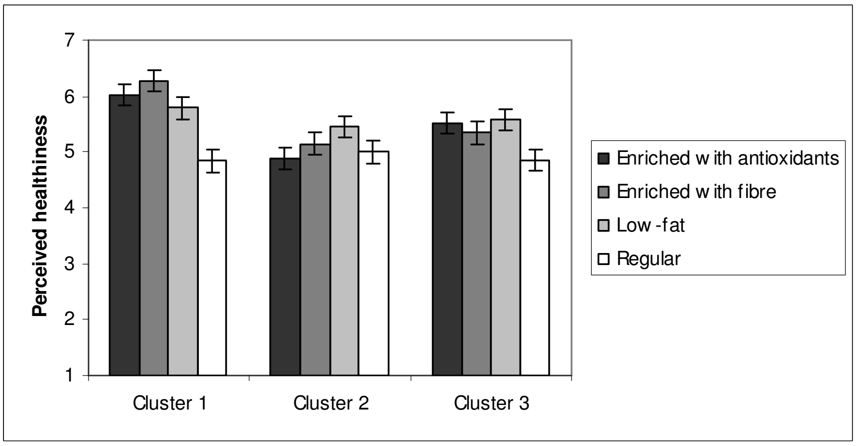
As shown in Figure 3.1, no significant differences were found between the perceived healthiness scores regular and low-fat products between participants in the three identified clusters. The lack of differences in the scores of the regular products suggests that all participants agreed on their healthiness, which could be explained considering that the evaluated products were frequently consumed and therefore their evaluations were not affected by the different level of nutritional knowledge. Regarding low-fat products, consumers scored them as significantly healthier than the corresponding regular ones. The agreement between clusters in the healthiness scores of the low-fat products could be attributed to the fact that Uruguayan consumers, as most Western populations, have been exposed to information about the role of fat on the prevention of cardiovascular diseases and weight control for several years. As most consumers are aware of the relationship of fat consumption and health, healthiness evaluations of low-fat products were similar for the three clusters. In order to verify this statement scores for each cluster were calculated for three sections of the questionnaire considering only the items related to fat. As shown in Table 3.7, the clusters only differed in their knowledge related to fat content of different foods. No differences were found in the degree of knowledge related to recommendations about fat consumption or the link between fat consumption and cardiovascular diseases.

On the other hand, highly significant differences between the clusters were found in the perceived healthiness scores of the products enriched with antioxidants and fibre (c.f. Figure 3.1), which could be explained by differences in the level of knowledge related to these compounds (Tables 3.5 and 3.7).

(a)



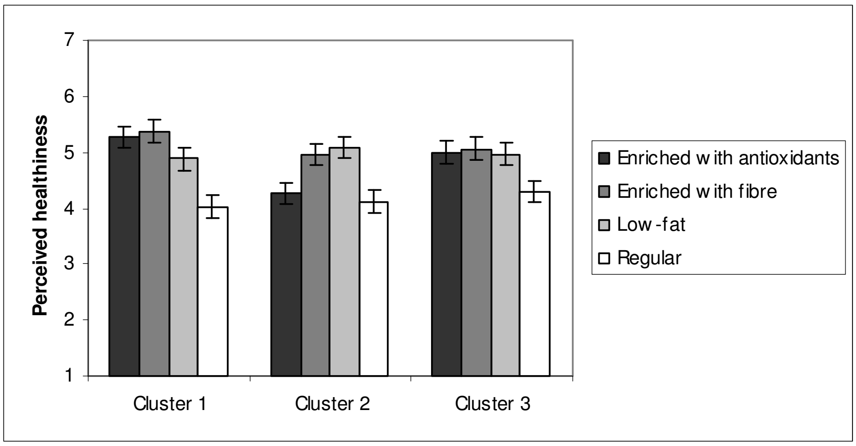
(b)



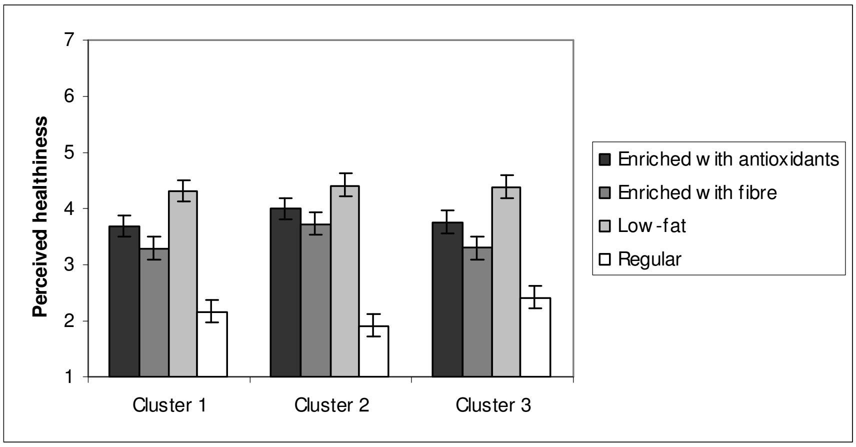
Vertical bars represent Tukey's honestly significant difference ($p \leq 0.05$)

Figure 3.1. Influence of three nutritional modifications on mean ratings for perceived healthiness of the four evaluated carrier products: **(a)** yogurt, **(b)** milk dessert, for the three clusters identified in the nutritional knowledge questionnaire.

(c)



(d)



Vertical bars represent Tukey's honestly significant difference ($p \leq 0.05$)

Figure 3.1 (cont.). Influence of three nutritional modifications on mean ratings for perceived healthiness of the evaluated carrier products: **(c)** pan bread and **(d)** mayonnaise, for the three clusters identified in the nutritional knowledge questionnaire.

Table 3.7. Mean scores of the nutritional questionnaire considering only those items related to fat and fibre for the three identified clusters in the nutritional knowledge questionnaire.

Nutrient	Nutritional Knowledge questionnaire item (maximum score)	Cluster 1 (n=45)	Cluster 2 (n=26)	Cluster 3 (n=33)
Fat	Experts' recommendations regarding healthy eating (2)	1.4 [a]	1.3 [a]	1.3 [a]
	Nutrient content of different foods (11)	8.5 [a]	5.0 [c]	6.3 [b]
	Links between diet and diseases (3)	2.9 [a]	2.4 [a]	2.8 [a]
Fibre	Experts' recommendations regarding healthy eating (1)	0.7 [a]	0.3 [a]	0.7 [a]
	Nutrient content of different foods (12)	9.1 [a]	3.6 [c]	5.7 [b]
	Links between diet and diseases (4)	2.8 [a]	1.1 [c]	2.8 [a]

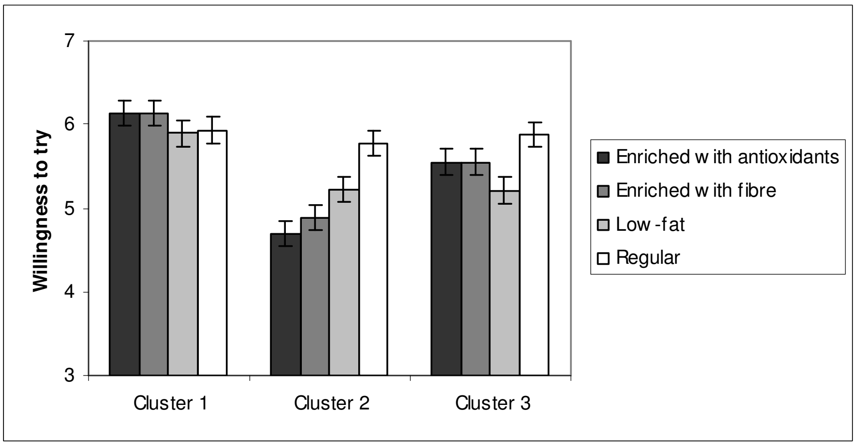
Values for the clusters with different superscripts within one row indicate that average scores are significantly different according to Tukey's test ($p \leq 0.05$)

As shown in Figure 3.1, except for yogurt, the enrichment with fibre or antioxidants was associated with a significant increase ($p<0.05$) in the perceived healthiness of the evaluated products for participants in Clusters 1 and 3. However, for participants in Cluster 2, the effect of the addition of fibre and antioxidants on perceived healthiness depended on the product. The addition of antioxidants to yogurt resulted in a decrease of perceived healthiness, whereas its addition to milk desserts or pan bread did not significantly change perceived healthiness with respect to the corresponding regular products. When mayonnaise was taken into account, the addition of both fibre and antioxidants resulted in an increase of healthiness scores. Therefore, differences in nutritional knowledge resulted in differences in healthiness perception of functional foods.

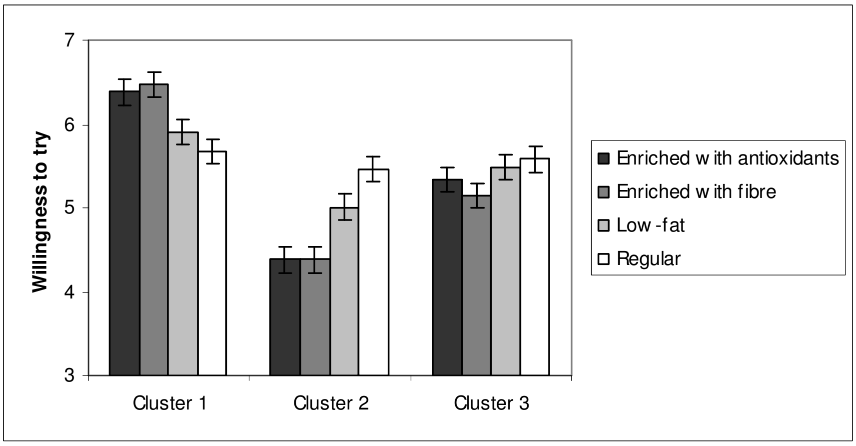
Although Clusters 1 and 3 showed different level of nutritional knowledge, similarities were found in their healthiness perception. However, as shown in Tables 3.5 and 3.7, these clusters did not differ much in their knowledge related to healthy eating recommendations and the links between diet and health. On the other hand, Cluster 2 differed from the other two in its degree of knowledge in these sections and was the cluster that behaved differently, not associating enrichment with fibre or antioxidants with an increase in healthiness.

The three groups of consumers also showed highly significant different willingness to try the evaluated products ($p<0.0001$). As shown in Figure 3.2, Cluster 1 showed the highest willingness to try when enrichments with fibre and antioxidants were considered for all investigated products, except for mayonnaise. The lack of interest in functional mayonnaise could be explained considering that consumers in this cluster were not interested in non-healthy products as carriers of functional foods. As shown in Figure 3.2, consumers in Cluster 3, which showed an intermediate level of nutritional knowledge, did not increase their willingness to try when antioxidants or fibre were added to yogurt, milk desserts, and pan bread. Finally, consumers in Cluster 2 decreased their willingness to try of all evaluated products when nutritional modifications were introduced. These results indicate that consumers with a low level of nutritional knowledge, particularly knowledge related to the health consequences of diet were not interested in consuming functional foods.

(a)



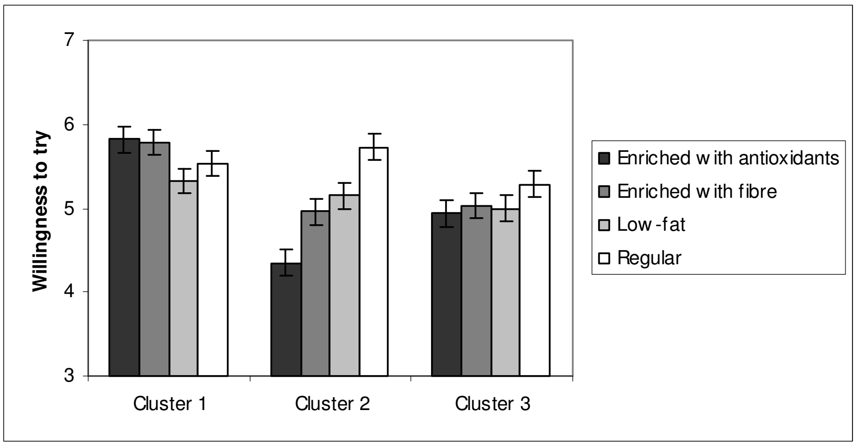
(b)



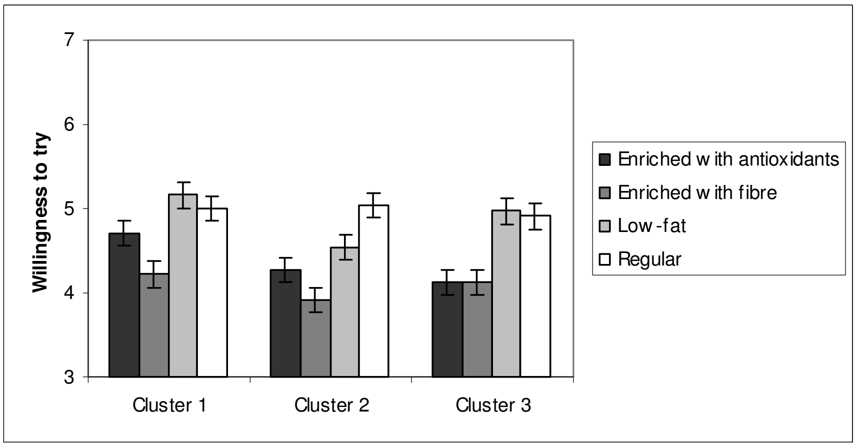
Vertical bars represent Tukey's honestly significant difference ($p \leq 0.05$)

Figure 3.2. Influence of three nutritional modifications on mean ratings for willingness to try the four evaluated carrier products: **(a)** yogurt, **(b)** milk dessert, for the three clusters identified in the Nutritional Knowledge Questionnaire.

(c)



(d)



Vertical bars represent Tukey's honestly significant difference ($p \leq 0.05$)

Figure 3.2 (cont). Influence of three nutritional modifications on mean ratings for willingness to try the evaluated carrier products: **(c)** pan bread and **(d)** mayonnaise, for the three clusters identified in the nutritional knowledge questionnaire.

On the contrary, consumers with the highest degree of knowledge were the most positive towards functional foods consumption. Consumers in Cluster 3, with an intermediate level of nutritional knowledge, showed an intermediate behavior, which could be related to the fact that they were less interested in health related issues.

3.2.3. DISCUSSION

Consumers' perceived healthiness of the evaluated regular and functional food concepts was more dependent on the carrier products than on the functional ingredient added to them, in agreement with results reported by van Kleef *et al*. (2005) and Ares & Gámbaro (2007). Therefore, these results suggest that prior beliefs about the healthiness of the carrier product might override the effect of functional ingredients or nutritional modifications.

The carrier*ingredient interaction was also significant, which indicates that certain combinations of carriers and functional ingredients were evaluated with a different perceived healthiness than would be expected from the separate carrier and ingredient evaluations. Therefore, certain functional ingredients might not have the same effect on the perceived healthiness when added to different carriers. While van Kleef *et al.* (2005) reported that Dutch consumers considered the contributions of health claims and carriers independently from each other, the studied sample of Uruguayan consumers seemed to evaluate the healthiness of nutritional modifications differently according to the product in which they are incorporated. This suggests that in Uruguay functional food design must be studied separately for each type of carrier product, as reported by Bech-Larsen & Grunert (2003) for Danish, Finnish and American consumers. Thus, the perceived healthiness of functional foods might depend on the characteristics of the consumers and the type of carrier and enrichment considered; indicating that no general trend can be established.

Yogurt and milk desserts showed the highest perceived healthiness, which indicates that Uruguayan consumers might perceive healthy products as credible carriers for functional messages.

In spite of considering functional products healthier than their conventional counterparts, consumers significantly decreased their willingness to try significantly lower. This could be attributed to lack of knowledge or interest about the potential health effects of the evaluated functional ingredients.

The nutritional knowledge of Uruguayan consumers seemed to be a little lower than that reported for European consumers by several authors (Wardle *et al.*, 2000; Parmenter & Wardle, 1999; Parmenter *et al.*, 2000; McPherson & Dunkeld Turnbull, 2000). Knowledge about recommendations regarding the intake of salt, fat, sugar and fibre was particularly low, suggesting that these basic messages are not yet successfully conveyed to the general population. Also, participants were not aware of the recommendation of eating at least five portions of fruits and vegetables a day, which could be attributed to the fact that there have not been any public campaigns in Uruguay to promote the intake of fruits and vegetables. Furthermore, the low level of nutritional knowledge related to the nutrient content of foods suggests that even if participants are aware of nutritional recommendations, the lack of knowledge in this area could limit the adoption of healthy dietary patterns or the consumption of functional foods. Although nutritional labeling is usual in Uruguay and compulsory since 2006, consumers seemed not be aware of the nutrient content of foods. This could be explained by the fact that Uruguayan consumers are not used to reading the information on the labels, as reported in Section 2.2. Considering that consumers do not always read nutritional information, alternative ways to communicate nutrient content of foods to people are needed, as well as public campaigns to get consumers accustomed to reading food labels.

It is important to remark that these results are not representative of the Uruguayan general population. However, as only middle-class consumers participated in the study it could be considered that nutritional knowledge in Uruguay might be even lower; which suggests that nutritional ignorance is a problem and public educational campaigns must be launched to increase nutritional knowledge of the population.

As stated by Urala & Lähteenmäki (2003) consumers might only consider consuming functional foods if they are perceived healthier than their conventional alternatives. Thus, in order to consider consuming a food product enriched with a certain functional ingredient consumers need to be aware of its potential health benefits. For this reason, knowledge about functional ingredients is likely to significantly affect consumers' perception of functional foods. As discussed above, participants showed a low level of nutritional knowledge, particularly of that related to fibre and antioxidants. This could lead to a low interest in functional foods enriched with these ingredients, as they are not aware of their health benefits.

Consumers with different degree of nutritional knowledge perceived the healthiness of functional foods enriched with fibre and antioxidants differently. Consumers with high or medium nutritional knowledge (i.e. consumers in Clusters 1 and 3 respectively) perceived products enriched with fibre or antioxidants as healthier than conventional ones. On the other hand, consumers with low level of nutritional knowledge (Cluster 2) decreased or maintained their perceived healthiness scores when fibre or antioxidants were added to yogurt, bread, or milk desserts. The main difference in knowledge about fibre and antioxidants between Clusters 1 and 3, and Cluster 2 was related to the effect of these nutrients on health. On the other hand, no significant differences were found between the clusters in their perceived healthiness scores of low-fat products. This could be related to the fact that no differences were found in knowledge about experts' recommendations about fat and links between fat consumption and health (c.f. Table 3.7). These results suggest that nutritional knowledge related to nutritional recommendations and the links between diet and health, might significantly affect healthiness perception of foods. This is in agreement with results reported by Wansink *et al.* (2005) for soy consumption. These authors stated that nutritional knowledge that most likely correlated with soy consumption is attribute-related knowledge of the food and consequence-related knowledge of how it would benefit them. Thus, the healthiness perception of foods might be related to knowledge about the links between diet and health.

When functional ingredients are added to different foods, consumers need to be aware of the health benefits of the ingredients in order to perceive functional foods as healthier than conventional ones. Thus, consumers that are not aware of the health benefits of a functional food might not be interested in consuming it, which could explain why consumers with the lowest level of nutritional knowledge (i.e. consumers in Cluster 2) were less willing to try functional foods than consumers with the highest level of nutritional knowledge. Consumers might at least know the relationship between the functional ingredient and health in order to be interested in functional foods. For this reason the use of health claims would be necessary in order to assure that consumers are aware of the health benefits of the product. Nevertheless, other important issue is how to communicate the health effects of functional foods reliably to consumers (Poulsen, 1999) as consumers might not necessarily trust in marketing campaigns. In this context, educational government campaigns could be important to increase interest in functional foods, as an alternative to improve the nutritional status of the population.

However, it is important to remark that knowledge is not the only determinant of consumers' interest in functional foods. Several authors have claimed that the influence of nutrition knowledge on food preferences and selection is rather small (Shepherd, 1992; Wardle *et al.*, 2000; Räsänen *et al.*, 2003), and therefore several factors may outweigh the influence of nutritional knowledge in interest on functional foods. One of these factors would probably be the interest in health and nutrition. Although consumers in Cluster 3 perceived functional foods as healthier than conventional ones, they were less interest in consuming the former. This difference between perceived healthiness and willingness to try stresses the fact that perceiving a food product as healthier does not necessarily mean trying it. Despite the fact that consumers more interested in health and nutritional issues have probably a higher level of nutritional knowledge, this relationship cannot be concluded from this study.

There is surely an interesting market segment for functional foods. Consumers in Cluster 1 were interested in functional foods and comprised approximately 40% of the sample under study. These consumers see products that are intrinsically healthy (yogurt, milk desserts, and pan bread) as credible carriers of functional messages, in agreement with Ares & Gámbaro (2007) and van Kleef *et al.* (2005). On the other hand, they are not interested in enrichment of 'non healthy' foods (i.e. mayonnaise), as reported by Bech-Larsen & Grunert (2003). However, the addition of fibre or antioxidants to yogurt did not cause an increase in their perceived healthiness or willingness to try. This suggests that products like yogurt are considered healthy as such and therefore nutritional modifications are not effective in increasing their perceived healthiness and consequently their willingness to try. Thus, it could be more interesting to develop functional foods using carrier products with an intermediate healthy image, such as pan bread or milk desserts.

3.2.4. PARTIAL CONCLUSIONS

Results from the present study showed that a significant relationship exists between nutritional knowledge, healthiness perception and willingness to try functional foods. Consumers with the highest nutritional knowledge were interested in functional foods. The addition of functional ingredients to products with an intermediate healthy image led to an increase in consumers' willingness to consume them when compared to the regular products. Milk desserts seem an interesting carrier product for the development of functional foods enriched with fibre or antioxidants. This product is usually consumed by several groups of consumers, including children and elderly people. Besides, there is increasing marketing activity in Uruguay regarding milk desserts, as most dairy companies have launched new low-fat and low-calorie desserts. Therefore, this product was selected as carrier for the upcoming studies.

Differences in nutritional knowledge related to nutritional recommendations and the links between nutrients consumption and health were the main reason for differences in healthiness perception and willingness to try functional foods among participants. These results suggest that this type of knowledge could affect consumers' interest in functional foods and therefore marketing strategies might be necessary to encourage functional foods consumption. Besides, the use of health claims might be necessary in order to assure that consumers are aware of the health benefits of the product and therefore consider substituting conventional foods by their functional alternatives. Further research is necessary to gather information about how to communicate health claims reliably to consumers.

3.3. INFLUENCE OF INGREDIENT, INGREDIENT NAME AND HEALTH CLAIM ON CONSUMERS PERCEIVED AND WILLINGNESS TO TRY A FUNCTIONAL MILK DESSERT

3.3.1. MATERIALS AND METHODS

3.3.1.1. Subjects

One hundred and fifty questionnaires were distributed at shopping areas, universities and public places in Montevideo (Uruguay) to people who volunteered to participate in the study. As part of the questionnaire, milk dessert frequency consumption was asked. Only people who consumed milk desserts at least once a week were considered. Thus, 82 questionnaires were selected to take part in the study. The sample included 46 females (55%) and 36 males (45%), ranging in age from 20 to 78 years (mean 37.3, standard deviation 14.9). Participants were sorted into two groups according to their age: 42 young people (between 20 and 34 years old), comprising 51% of the sample, and 40 old people (older than 35 years), comprising 49% of the sample.

3.3.1.2. Conjoint study

Considering results from Section 3.2, a milk dessert was selected as carrier product. The conjoint design consisted of three categorical factors: type of functional ingredient (two levels: enriched with antioxidants or fibre), name of the ingredient (two levels: declared using a common or a scientific name), and claim (three levels: 'no claim', 'enhanced function' claim or 'reduced disease risk' claim). Table 3.8 summarizes factors and levels used in the study. The three factors were varied independently of each other, following a full factorial design. This design resulted in 12 (2*2*3) combinations of attributes plus a regular milk dessert (without the addition of any ingredient and without any health claim, presented to consumers as 'milk dessert'), which was used as control. Therefore, participants evaluated a total of 13 milk dessert concepts, which are presented in Table 3.9. All the information was presented using cards with images like the one shown in Figure 3.3. Images were printed in glossy paper and coated with contact paper.

Table 3.8. Attributes and levels description for the conjoint analysis

Factor	***Level and Description***
Functional ingredient	1.- Fibre 2.- Antioxidants
Name of the ingredient	1.- Common (Fibre, Antioxidants) 2.- Scientific (β-glucan, Flavonoids)
Claim	1.- No Claim 2.- 'Enhanced function' claim Fibre: *'Encourage calcium absorption and growth of beneficial bacteria in the gut'* Antioxidants: *'Prevents body fat oxidation and favours cellular health'* 3.- 'Reduced disease risk' claim Fibre: *Reduce the risk of cancer in the gut'* Antioxidants: *'Reduce the risk of heart disease and certain kinds of cancer'*

Table 3.9. Description of the 13 milk desserts presented to participants and corresponding attribute levels (c.f. Table 3.8).

Description	Functional ingredient	Ingredient name	Health claim
Milk dessert (*)	-	-	-
Milk dessert containing fibre	1	1	1
Milk dessert containing β-glucans	1	2	1
Milk dessert containing antioxidants	2	1	1
Milk dessert containing flavonoids	2	2	1
Milk dessert containing fibre. *'Fibre consumption encourage calcium absorption and growth of beneficial bacteria in the gut'*	1	1	2
Milk dessert containing fibre. *'Fibre consumption reduce the risk of cancer in the gut'*	1	1	3
Milk dessert containing β-glucans. 'β-glucans consumption encourage calcium absorption and growth of beneficial bacteria in the gut'	1	2	2
Milk dessert containing β-glucans. *'β-glucans consumption reduce the risk of cancer in the gut'*	1	2	3
Milk dessert containing antioxidants. *'Antioxidants consumption prevents body fat oxidation and favours cellular health'*	2	1	2
Milk dessert containing antioxidants. *'Antioxidants consumption reduce the risk of heart disease and certain kinds of cancer'*	2	1	3
Milk dessert containing flavonoids. *'Flavonoids consumption prevents body fat oxidation and favours cellular health'*	2	2	2
Milk dessert containing flavonoids. *'Flavonoids consumption reduce the risk of heart disease and certain kinds of cancer'*	2	2	3

(*) Regular milk dessert, used as control

Figure 3.3. Example of two functional milk dessert images used in the conjoint analysis study to present the information.

Images were presented to participants numbered with three-digit random codes. Participants were asked to score the perceived healthiness of the different images, using a 7-box scale labelled on the left with 'not at all healthy' and on the right with 'very healthy', and to score their willingness to try them using a 7-box scale labelled on the left with 'I would definitely not try it', on the middle with 'Maybe yes, maybe not' and on the right with 'I would definitely try it'.

Most consumers were not aware of the health effects of fibre and antioxidants and had never heard the terms 'β-glucans' or 'flavonoids' before the study. Thus, if consumers have read a card that related a functional ingredient with a health benefit (e.g. by reading 'glucans consumption can decrease the risk of cancer in the gut') they would have associated the ingredient with the health benefit in the upcoming evaluations. Therefore, in order to minimize the influence of the information presented on some of the cards on consumers evaluations, figures were presented in the following order: first participants evaluated the figure corresponding to the regular milk dessert, then they evaluated figures corresponding to desserts without any type of claims and finally images corresponding to deserts with enhanced function and reduced disease risk claim.

Figures within each category were presented in random order, which eliminated the possibility of order effects. Using this presentation order, consumers first evaluated how healthy they thought a milk dessert and milk desserts with different functional ingredients were. This evaluation was based on consumers' previous knowledge about the ingredients, without any type of external influence or information. Then, consumers evaluated the same functional milk desserts but now having information about their effect on health.

3.3.1.3. Data analysis

Analysis of variance (ANOVA) was performed on data from perceived healthiness and willingness to try. The ANOVA method used in the present study was the following (Naes *et al.*, 2001):

Y = mean + main effects for conjoint variables + main effects for consumer variables + interactions among conjoint variables + interactions among consumer conjoint and consumer variables + random error

The main effects consisted on both the main effects in the conjoint design (functional ingredient, name and claim) and the main effects for consumer variables (gender and age group). All interactions among conjoint variables were considered, while first and second order interactions among conjoint and consumer variables were considered. When the effects were significant, honestly significant differences were calculated using Tukey's test. Differences were considered significant when $p \leq 0.05$.

All statistical analyses were performed using GenStat for Windows Discovery Edition 2 (VSN International, Hemel Hempstead, UK).

3.3.2. RESULTS AND DISCUSSION

3.3.2.1. Conjoint analysis

Consumers scored the healthiness and willingness to try of the regular milk dessert as intermediate, as they score it 4.3 and 4.5 respectively in the 7 point scale used.

ANOVA revealed that the main effects of the conjoint variables name and claim were highly significant for both perceived healthiness and willingness to try, whereas the effect of functional ingredient was not significant, as shown in Table 3.10. The only significant interaction among conjoint variables was name*claim, indicating that certain combinations of names and claims were evaluated as more/less healthy that would be expected from separate name and claim evaluations.

As shown in Table 3.11, healthiness and willingness to try increased with the addition of fibre and antioxidants when compared to the regular milk dessert, indicating a positive attitude towards these functional ingredients. These results suggest that this type of product could reach an interesting market in Uruguay. Consumers showed the same attitude towards milk desserts enriched with fibre or antioxidants (c.f. Tables 3.10 and 3.11), indicating that they might be equally interested in their addition to milk desserts.

The type of name used to identify the added ingredient had a highly significant influence on consumers' evaluations. The use of common names such as fibre or antioxidants resulted in a marked increase of both healthiness and willingness to try when compared to the use of compound or scientific names (Table 3.11).

Table 3.10. p-values for fixed effects tested in the ANOVA for healthiness and willingness to try scores

Effect	***Healthiness***	***Willingness to try***
Gender	0.0001*	0.0023*
Age	0.6021	<0.0001*
Functional ingredient	0.3096	0.3682
Name	<0.0001*	0.0001*
Claim	<0.0001*	<0.0001*
Gender*Functional ingredient	0.7838	0.5127
Gender*Name	0.2265	0.2312
Gender*Claim	0.0467*	0.5347
Age*Functional ingredient	0.9439	0.8700
Age*Name	0.1404	0.1645
Age*Claim	0.7111	0.4949
Functional ingredient*name	0.1237	0.1103
Functional ingredient*Claim	0.3583	0.5583
Name*Claim	0.0006*	0.0111*
Functional ingredient*Name*Claim	0.3587	0.4539

* significant effect ($p \leq 0.05$)

Therefore, consumers might be more prone to purchasing and consuming functional foods with functional ingredients that are familiar to them. The use of compound or scientific names might not be recommended as they could have a negative impact on consumers' perception of the product.

Table 3.11. Average scores for control milk dessert and significant effects in the ANOVA of healthiness and willingness to try scores

	Average score	
	Healthiness	**Willingness to try**
Regular milk dessert	4.2	4.5
Functional ingredient		
Fibre	5.4 [a]	5.2 [a]
Antioxidants	5.3 [a]	5.1 [a]
Name		
Scientific	5.2 [a]	4.9 [a]
Common	5.6 [b]	5.4 [b]
Claim		
No claim	4.4 [a]	4.3 [a]
'Enhanced function' claim	5.8 [b]	5.6 [b]
'Disease reduced risk' claim	5.9 [b]	5.6 [b]
Gender		
Male	5.2 [a]	5.0 [a]
Female	5.6 [b]	5.3 [b]
Age		
Young	5.4 [a]	4.9 [a]
Old	5.4 [a]	5.4 [b]
Name*Claim		
Scientific - No claim	4.0 [a]	3.9 [a]
Common - No Claim	4.9 [b]	4.7 [b]
Scientific - Enhanced function claim	5.7 [c]	5.4 [c]
Scientific - Reduced disease risk claim	5.8 [c,d]	5.6 [c,d]
Common - Reduced disease risk claim	5.9 [d]	5.7 [d]
Common - Enhanced function claim	5.9 [d]	5.7 [d]

Mean values sharing the same letter within a column and category are not significantly different (p>0.05)

The use of these names without health claims caused a decrease in healthiness perception and willingness to try when compared to the regular milk dessert, as shown in Table 3.11. Therefore, the use of this information on labels could reduce consumers' interest in the product due to unfamiliarity with the terms. However, when claims were used, functional products in which the ingredients were declared using scientific names were better evaluated than the regular dessert, probably because they associated the ingredient with its effect on health.

On the contrary, when common names were used consumers perceived functional milk desserts as healthier than the regular one, even if no health claims were used. Therefore, if a functional food manufacturer wants to emphasize the use of a novel ingredient, the ingredient could be declared using its scientific name but incorporating a health claim on the label.

Both kinds of claims had a positive impact on consumers' perception of the healthiness of milk desserts and willingness to try compared to milk desserts without claims (Table 3.11). Therefore, Uruguayan consumers might consider the possibility of consuming functional foods for achieving a positive effect on their health. Bech-Larsen & Grunert (2003) found similar results for consumers in Denmark, Finland and United States. According to Levy *et al.* (1997) American consumers' perceptions of the healthiness of functional foods are rather based on prior beliefs about the type of carrier product than on specific health claims. However, Uruguayan consumers seemed to consider health claims when evaluating the healthiness of functional foods. This could also be attributed to the fact that Uruguayan consumers are not much aware of the health effects of fibre and antioxidants (c.f. Section 3.2) and therefore increase their healthiness evaluations when health claims are used. Uruguayan consumers are not familiar with these types of claims as they are not yet used in functional foods in local market. Therefore, the use of health claims could be a useful way to increase functional foods consumption.

When claims were used, perceived healthiness and willingness to try were not significantly different for products with ‘enhanced function’ or ‘reduced disease risk’ claims. Consumers showed the same attitude towards both types of claims, suggesting that they might not be affected by confronting with illness and problems they might suffer in the future. These results indicate that both type of claims could be included in functional foods’ labels and might be appealing for consumers.

When no claims and common names were used, functional milk desserts enriched with antioxidants were evaluated as significantly healthier and with a higher willingness to try (5.1 and 4.9 respectively) than that enriched with fibre (4.7 and 4.5 respectively). This could be attributed to the fact that Uruguayan consumers might be more aware of the positive health effects of antioxidants, probably to increasing market activity regarding functional mineral waters enriched with antioxidants.

3.3.2.2. Influence of gender and age

Socio-demographic variables, such as gender and age, might have a great influence in determining the acceptance of functional foods. Differences in attitude towards functional foods with gender and age have been reported to depend on the product being considered (Ares & Gámbaro, 2007). In the present study differences in functional milk desserts acceptance were found with gender and age. According to de Jong *et al.* (2003), gender, age and education significantly affect the use of the functional food but their influence depends on the specific functional food product being considered. As shown in Table 3.10, the main effect of gender was highly significant for perceived healthiness and willingness to try, suggesting differences between males and females in healthiness perception and interest in the functional milk desserts. Regarding age, significant differences were found only for willingness to try. This suggests that both age groups evaluated the healthiness of the products equally but presented different interest in trying them, indicating that functional foods consumption is affected by other factors apart from their perceived healthiness.

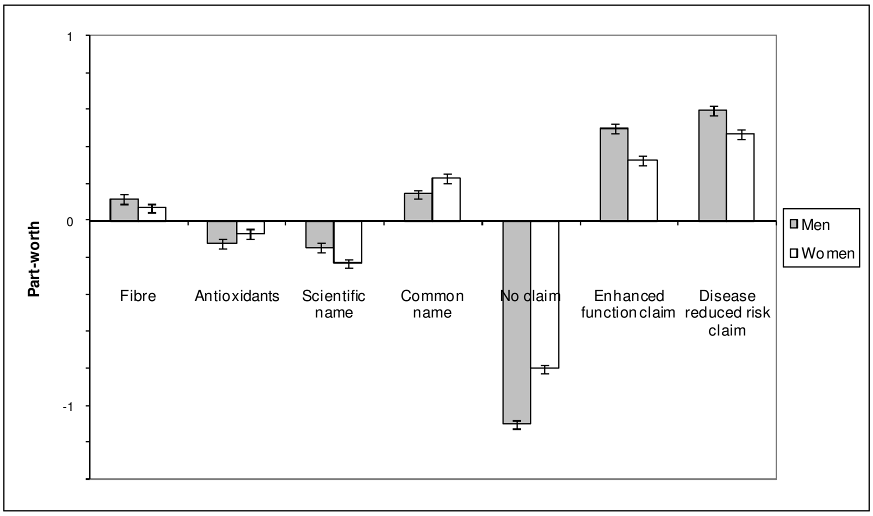
Women gave slightly higher scores than men to the healthiness and willingness to try of the evaluated products (5.6 *vs* 5.2 for healthiness and 5.3 *vs* 5.0 for willingness to try). This indicates that they were more positive to the type of functional food considered. Women have been reported to be more interested in functional foods (Childs & Poryzees, 1998; Poulsen, 1999), to be more familiar with functional food products and more frequently use functional foods than men (Bogue & Ryan, 2000; Niva *et al.*, 2003).

Mean effects part-worth differences for perceived healthiness and willingness to try are shown in Figure 3.4 for men and women. Women seemed to give more importance to the type of name used to declare the addition of the functional ingredient, as utilities for name were significantly higher than those for men. This could suggest that women are more familiar with the health effects of fibre and antioxidants than men. This assumption is strengthened by the fact that the utilities for claims were lower for women than for men. The larger differences with gender were found when functional ingredients were declared using common names without claims. Women evaluated milk desserts enriched with fibre and antioxidants without health claims as much healthier than men.

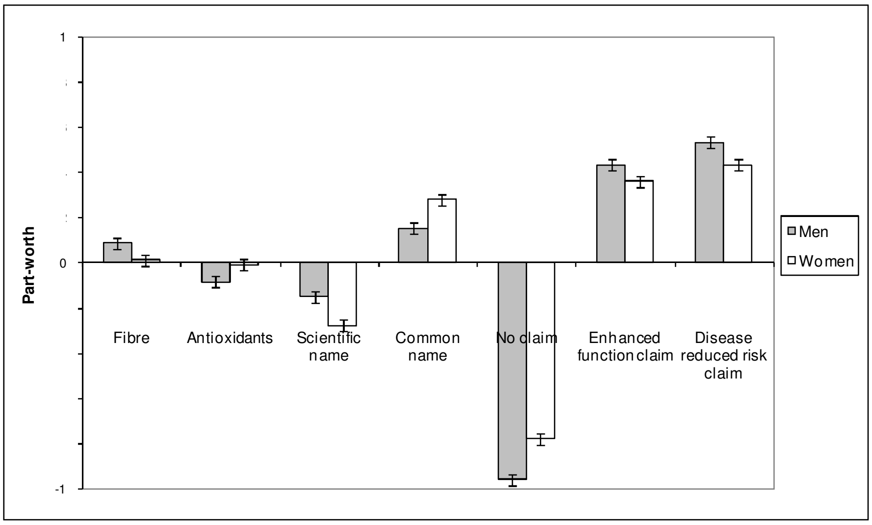
Women scored the healthiness of milk desserts enriched with antioxidants and fibre as 5.6 and 5.1 respectively, whereas men scored it as 4.6 and 4.3. The same trend was found for willingness to try. These differences were smaller when health claims were incorporated, indicating that perception differences were due to the fact that women were more aware of the health effects of fibre and antioxidants on health than men. These results are in agreement with results reported by Ares & Gámbaro (2007), in which women were more positive towards fibre enrichment in yogurt, *dulce de leche*, soup and marmalade than men.

Regarding age, although there were no significant difference in perceived healthiness, older people scored the willingness to try of the products higher ($p<0.05$), suggesting that they were more interested in consuming such products. These results are in agreement with published data by Childs (1997), IFIC (1999) and Poulsen (1999). These authors reported that older consumers have been identified as more likely to adopt functional foods in their diets. On the other hand, Verbeke (2005) reported that age and gender did not affect functional foods acceptance for Danish consumers.

(a)



(b)



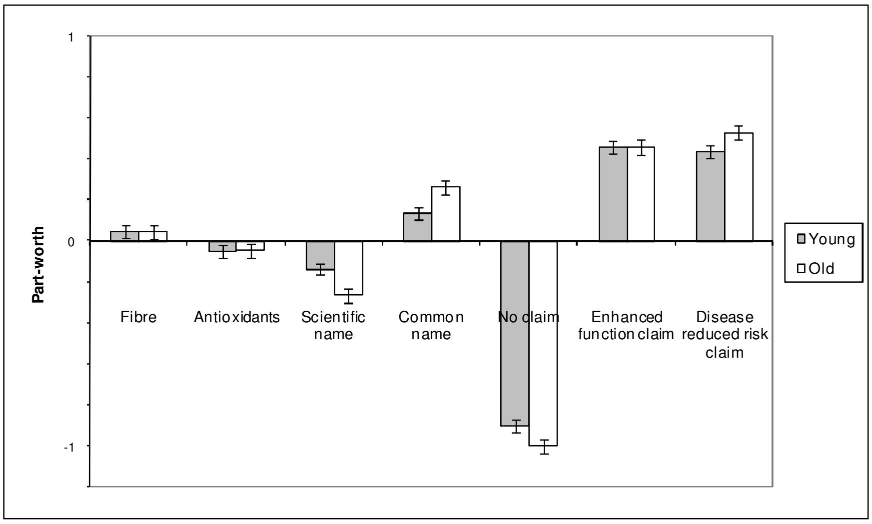
Vertical lines represent standard deviations.

Figure 3.4. Part worth-utilities for the main effects for **(a)** perceived healthiness and **(b)** willingness to try, for men and women.

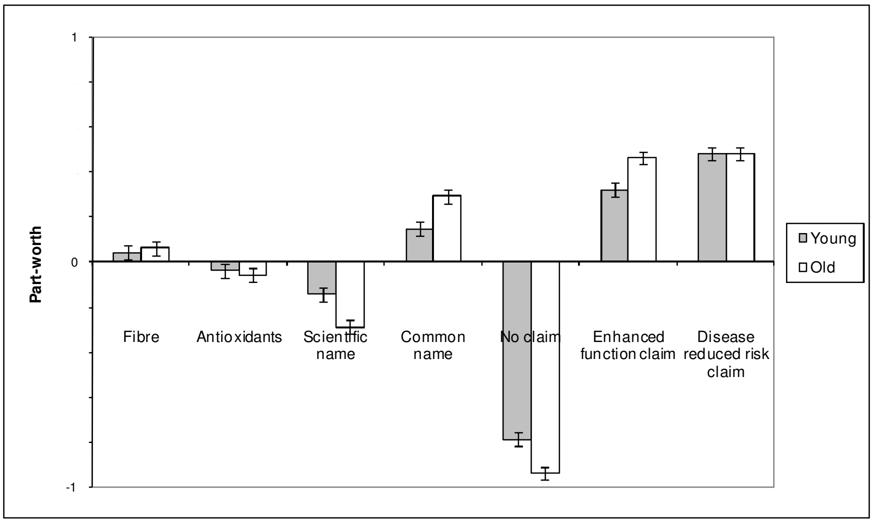
Mean effects part-worth differences for perceived healthiness and willingness to try are shown in Figure 3.5 for young and old consumers. Young consumers seemed to give less importance to how the functional ingredient is declared, as the name had lower utility than for old participants. This could be attributed to the fact that old consumers are more familiar with antioxidants and fibre than young ones, as the former might be more interested in finding products that could have a positive impact on their heath. Also, young people were less positive than old ones to 'enhanced function claims', as shown in Figure 3.5. While old consumers gave the same utility for both types of claims, young individuals seemed to prefer 'disease reduced risk' claims. Although no significant differences were found in their healthiness evaluation, old participants gave significantly higher willingness to try scores to products with 'enhanced function' claims than young participants (data not shown). These results suggest that younger people seemed to emphasize the disease preventing claims, while older people tended to be also interested in claims that focus short term effects on health.

In the present study, health claim was the variable with the highest relative importance, suggesting that health claims might be important for increasing the attractiveness of functional foods. Moreover, different health claims could be attractive to different market segments and therefore health claims should be designed according to which segment of the market the product is addressed to.

(a)



(b)



Vertical bars represent standard deviations.

Figure 3.5. Part worth-utilities for the main effects for **(a)** perceived healthiness and **(b)** willingness to try for young and old consumers.

3.3.3. PARTIAL CONCLUSIONS

Consumers showed the same attitude towards milk desserts enriched with fibre or antioxidants, indicating that they might be equally interested in their addition to milk desserts. The use of compound or scientific names might not be recommended as they could have a negative impact on consumers. However, if a functional food manufacturer wants to emphasize the use of a novel ingredient using its scientific name, it is recommended to incorporate a health claim on the label, in order to achieve an association in consumers' mind between the ingredient and its health effect. Consumers showed the same attitude towards 'enhanced function' or 'reduced disease risk' claims.

Women and old people seemed to be the most positive groups towards functional foods. Women seemed to give more importance to the type of name used regarding the functional ingredient, which could be probably attributed to the fact that women are more familiar with the health effects of fibre and antioxidants than men. Besides, young people emphasized the disease preventing claims, while older people tended to be also interested in claims that focus on short term effects on health.

3.4. INFLUENCE OF INFORMATION ABOUT THE SOURCE OF FUNCTIONAL INGREDIENTS ON CONSUMERS' PERCEPTION OF FUNCTIONAL MILK DESSERT CONCEPTS

3.4.1. MATERIALS AND METHODS

3.4.1.1. Participants

The study was conducted in the city of Montevideo, Uruguay. One-hundred people participated in the study; 38% of which were males and 62% females. Participants ranged in age from 18 to 84 years old (mean 36.1 years old, standard deviation 17.1 years old). All participants consumed milk desserts at least once a week, and were randomly recruited at shopping areas, universities campus and public places.

3.4.1.2. Stimuli

The carrier product for the present study was a milk dessert. Two functional ingredients were studied: fibre and antioxidants. Three sources were considered for each functional ingredient: Marcela (*Achiroclyne satureoides*), Guaco (*Mikania* guaco) and Carqueja (*Baccharis trimera*) (native Uruguayan plants with medicinal uses) for antioxidants; and Oat, Barley and *Pleurotus* mushrooms for fibre.

Five concepts of milk desserts were considered for each functional ingredient: regular milk dessert, milk dessert enriched with the functional ingredient, and milk desserts enriched with the functional ingredients from the three selected sources. The milk desserts concepts considered are summarized in Table 3.12.

Table 3.12. Concepts of milk dessert enriched with antioxidants and fibre from different sources considered in the study.

Functional ingredient	Milk desserts considered
Antioxidants	1. Milk dessert 2. Milk dessert enriched with antioxidants 3. Milk dessert enriched with antioxidants from Marcela 4. Milk dessert enriched with antioxidants from Guaco 5. Milk dessert enriched with antioxidants from Carqueja
Fibre	1. Milk dessert 2. Milk dessert enriched with fibre 3. Milk dessert enriched with fibre from Oat 4. Milk dessert enriched with fibre from Barley 5. Milk dessert enriched with fibre from Pleurotus mushrooms

The concepts, as described in Table 3.12, were presented to consumers using a picture of a vanilla milk dessert. An example of an image used in the study is shown in Figure 3.6. Images were printed in glossy paper and coated with contact paper, and were presented to participants numbered with three-digit random codes. Images were grouped by functional ingredient, and consumers evaluated them in random order to minimize presentation order effect. The ten images, grouped by functional ingredient, were presented to each participant.

Participants were asked to score the perceived healthiness of the different images, using a 7-box scale labelled on the left with ‘not at all healthy’ and on the right with ‘very healthy’; to indicate their expected liking of the product, using a 7-box scale labelled on the left with ‘dislike very much’, ‘indifferent’ in the middle, and on the right with ‘like very much’; and to score their willingness to buy them using a 7-box scale labelled on the left with ‘I would definitely not buy it’, on the middle with ‘Maybe yes, maybe not’ and on the right with ‘I would definitely buy it’.

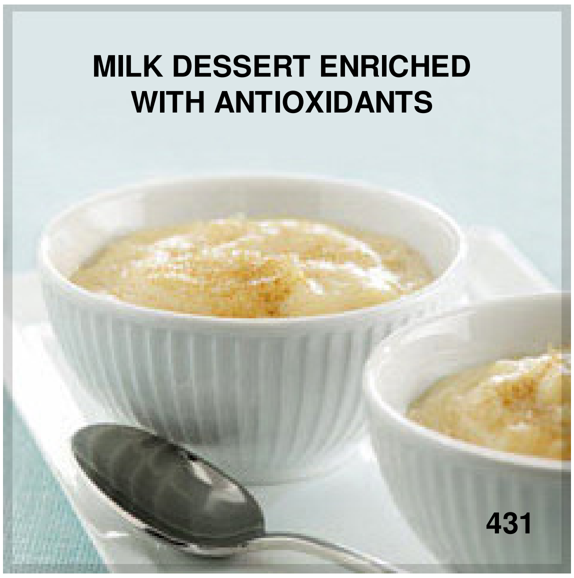


Figure 3.6. Example of how information about functional milk desserts was presented to participants in the study.

After evaluating the five concepts of milk desserts for each functional ingredient, respondents were asked to answer the question ‘If you were to choose to buy a milk dessert, which one would you buy?’.

Finally, participants were asked to answer a questionnaire about their attitudes towards health and hedonic characteristics of foods. The attitudinal questionnaire was developed by modifying some items from published works (Steptoe *et al.*, 1995; Roininen *et al.*, 1999) and by adding some new items (as those related to the type of functional ingredients considered in the present study).

Participants had to endorse their degree of agreement with 20 statements using a 7-box scale anchored with ‘I completely disagree’ on the left and ‘I completely agree’ on the right. The questionnaire is shown in Appendix F.

3.4.1.3. Data analysis

Analysis of variance (ANOVA) was performed on data from expected liking, perceived healthiness and willingness to purchase for each functional ingredient. The analysis was performed considering concept and participant as fixed sources of variation. When an effect was significant, honestly significant differences were calculated using Tukey’s test considering $p \leq 0.05$.

A multiple linear regression was performed considering willingness to purchase scores as dependent variable and expected liking and perceived healthiness as explanatory variables.

In order to identify groups of consumers who had different attitudes towards health and hedonics characteristics of foods, a hierarchical cluster analysis was performed on data from attitudinal questionnaire. Euclidean distances and Ward’s aggregation method were considered.

The existence of differences between the clusters gender frequency distributions was evaluated using the chi-squared statistical test.

An ANOVA was performed on data from expected liking, perceived healthiness and willingness to purchase for each functional ingredient considering concept, cluster and their interaction as fixed sources of variation.

All these statistical analyses were performed using GenStat for Windows Discovery Edition 2 (VSN International, Hemel Hempstead, UK).

3.4.2. RESULTS AND DISCUSSION

3.4.2.1. Expected liking, perceived healthiness and willingness to purchase

The evaluated milk dessert concepts highly significantly ($p<0.001$) differed in their expected liking, perceived healthiness and willingness to purchase scores.

As shown in Table 3.13, the addition of fibre or antioxidants to milk desserts led to an increase in perceived healthiness, suggesting that consumers were partly aware of the health benefits of these functional ingredients and reacted positively to their addition to milk desserts. Regarding expected liking, there were no significant differences in the scores of regular milk desserts and those enriched with antioxidants and fibre. This indicates that consumers might not expect changes in the sensory characteristics of milk desserts due to the addition of such compounds. Besides, despite the increase in perceived healthiness as a result of the addition of fibre or antioxidants, the addition of these functional ingredients to milk desserts did not increase consumer intention to purchase.

Scores for expected liking decreased when information about the source of fibre or antioxidants was included. This could be attributed to the fact that when consumers knew the source of the functional ingredient they expect to find a milk dessert having the flavour of the source and therefore they decrease their expected liking. Information about the source of functional ingredients did not increase perceived healthiness with respect to the generic functional ingredient; suggesting that consumers mainly consider the functional ingredient and not its source for evaluating the healthiness of functional foods.

Table 3.13. Scores[§] for expected liking, perceived healthiness and willingness to purchase for milk desserts enriched with antioxidants and fibre from different sources.

Milk dessert	Expected liking	Perceived healthiness	Willingness to purchase
Regular	5.5 ^{a}	5.1 ^{b}	5.5 ^{a}
Enriched with fibre	5.3 ^{a}	5.8 ^{a}	5.3 ^{a}
Enriched with fibre from Oat	4.8 ^{b}	5.8 ^{a}	4.9 ^{b}
Enriched with fibre from Barley	4.3 ^{c}	5.3 ^{b}	4.3 ^{c}
Enriched with fibre from *Pleurotus* mushrooms	3.2 ^{d}	4.4 ^{c}	3.0 ^{d}
Regular	5.7 ^{a}	5.1 ^{c}	5.4 ^{a}
Enriched with antioxidants	5.3 ^{a}	6.0 ^{a}	5.3 ^{a}
Enriched with antioxidants from Marcela	4.1 ^{b}	5.4 ^{b,c}	4.1 ^{b}
Enriched with antioxidants from Guaco	4.4 ^{b}	5.6 ^{c}	4.4 ^{b}
Enriched with antioxidants from Carqueja	4.2 ^{b}	5.3 ^{b,c}	4.1 ^{b}

Values with different superscripts within one column for each functional ingredient are significantly different according to Tukey's test ($p \leq 0.05$). [§] evaluated in 7-box scales

The influence of information about the source of functional ingredients on perceived healthiness depended on the source being considered. As shown in Table 3.13, except for fibre from oat, information about the source of functional ingredients led to a decrease in perceived healthiness when compared to functional milk desserts without information about the source of the functional ingredient. This could be attributed to the fact that they not associate the functional ingredient with its source. In the case of fibre, milk desserts enriched with fibre from *Pleurotus* mushroom were perceived as less healthy than the regular milk dessert, probably due to lack of familiarity with this product. On the other hand, milk desserts enriched with fibre from oat were perceived as healthy as those enriched with fibre. This could be attributed to the fact that consumers are already used to consume oat products and might be aware of the high fibre content of oat. Therefore, familiarity with functional ingredients and their sources might also play an important part in functional foods acceptance.

The decrease in expected liking due to the inclusion of information about the source of functional ingredients led to a decrease in willingness to purchase, indicating that expected liking might be crucial in determining consumer acceptance of functional foods. A multiple linear regression was performed for explaining willingness to purchase scores as a function of expected liking and perceived healthiness. The expression found explained 98.8% of the variance of the experimental data and was the following:

$$\text{Willingness to purchase} = -0.85 + 0.96{*}\text{Expected liking} + 0.19{*}\text{Perceived healthiness} \quad (1)$$

As shown in Eq. (1), although willingness to purchase functional milk desserts depended both on expected liking and perceived healthiness, the influence of hedonic characteristics was higher. These results are in agreement with Poulsen (1999), Verbeke (2006), Gilbert (2000), Tuorila & Cardello (2002), and Childs & Poryzees (1998); indicating that hedonic expectations are a crucial factor for the acceptance of functional foods, as consumers might not be willing to compromise taste for health. Therefore, functional ingredients should be added to food products without changing their sensory characteristics.

Table 3.14 shows consumer choices for milk dessert concepts for each functional ingredient. Concepts of milk desserts enriched with fibre and antioxidants without specifying their source were chosen as most likely to buy more frequently than the other desserts, suggesting that consumers might be interested in this type of product.

Table 3.14. Frequencies in which the five milk dessert concepts for each functional ingredient were chosen as most likely to buy for the whole consumer sample.

Milk dessert	Percentage of consumers
Regular	21%
Enriched with fibre	45%
Enriched with fibre from Oat	27%
Enriched with fibre from Barley	5%
Enriched with fibre from *Pleurotus* mushrooms	1%
Regular	22%
Enriched with antioxidants	60%
Enriched with antioxidants from Marcela	12%
Enriched with antioxidants from Guaco	5%
Enriched with antioxidants from Carqueja	1%

Although no significant differences were found in their willingness to purchase scores, desserts enriched with fibre or antioxidants were chosen as most likely to buy more frequently than regular milk desserts. This suggests that willingness to purchase scores were not predictive of consumer forced choice decisions. In this case, although when scoring their intention to purchase regular and functional milk desserts were considered similarly, consumers preferred functional milk desserts when facing purchase choice decision. Willingness to purchase scales were not able to predict consumers' responses when facing a purchase decision.

3.4.2.2. Cluster analysis

Hierarchical cluster analysis was performed on the attitudinal questionnaire shown in Table 3.15. This analysis was performed in order to evaluate if consumers showing different attitudes towards health and hedonic characteristics of foods reacted differently towards information about the source of functional ingredients. In this analysis, two clusters were identified; Cluster 1 composed of 57 participants and Cluster 2 composed of 43 individuals.

Highly significant differences were found between clusters' ratings for 10 out of the 20 statements of the questionnaire, as shown in Table 3.15. Although both clusters agreed on the importance of diet on health and the importance of hedonic characteristics in their everyday food choices, there were highly significant differences in their interest in health-related issues. Participants in Cluster 2 were more concerned about maintaining their health (items 6-8), had a more balanced diet (item 16-17) and were more willing to consume healthy products (item 18) than participants in Cluster 1; suggesting that they might be more interested in consuming functional food products. This higher interest in health led to a higher willingness to compromise liking for healthiness (items 5, 19-20), as shown in Table 3.15. This is in agreement with Verbeke (2006) who reported that health benefit belief from functional foods was the strongest positive determinant of willingness to compromise taste for health.

Table 3.15. Items of the attitudinal questionnaire about health and hedonic characteristics of foods and average scores for each of the two identified clusters.

Statements	Average score	
	Cluster 1 (n = 57)	Cluster 2 (n = 43)
1. Diet is important for my health	6.7 [a]	7.0 [a]
2. I always eat food products that I like	6.4 [a]	6.5 [a]
3. Consuming some food products could have a positive impact on my health	6.7 [a]	7.0 [a]
4. Consuming certain food products could help preventing some diseases	6.5 [a]	6.9 [a]
5. Food products should not necessarily be a source of pleasure	2.5 [b]	6.0 [a]
6. I do all I can to keep myself healthy	4.7 [b]	6.1 [a]
7. I am willing to make sacrifices to keep myself healthy	4.3 [b]	5.8 [a]
8. I am interested in taking measures for preventing the occurrence of some diseases	5.4 [b]	6.5 [a]
9. I do not take into account the appearance of food when deciding what to eat	2.8 [a]	2.5 [a]
10. Food products should have a taste that I like	6.6 [a]	6.5 [a]
11. I am interested in losing weight	4.2 [a]	3.8 [a]
12. I am interested in enjoying the taste of foods	6.5 [a]	6.7 [a]
13. High fibre intake could decrease the risk of some diseases	6.1 [a]	6.3 [a]
14. Antioxidants intake could decrease the risk of some diseases	6.2 [a]	6.7 [a]
15. Food products should have a taste that I like	6.4 [a]	6.1 [a]
16. Healthiness and nutritional content have a high impact on my food choices	4.5 [b]	5.1 [a]
17. I always follow a healthy and balanced diet	4.7 [b]	5.8 [a]
18. I am willing to consume products that have a positive impact on my health	6.1 [b]	6.7 [a]
19. I am interested in consuming products that have a positive impact on my health even if I don't like them as much as others	3.9 [b]	5.7 [a]
20. I consume highly nutritious products that I don`t like	2.6 [b]	3.6 [a]

Values with different superscripts within one row indicate that average scores for Cluster 1 and Cluster 2 are significantly different according to Tukey's test ($p \leq 0.05$).

Participants in Cluster 2 scored their agreement with the statement '*I am interested in consuming products that have a positive impact on my health even if I don't like them as much as others*' in 5.7, which suggests that they might be willing to accept functional foods even if the taste worse than conventional foods. Willingness to compromise on sensory characteristics when making decisions about functional and healthy products was higher than that reported in Belgium for both 2001 and 2004 (Verbeke, 2006).

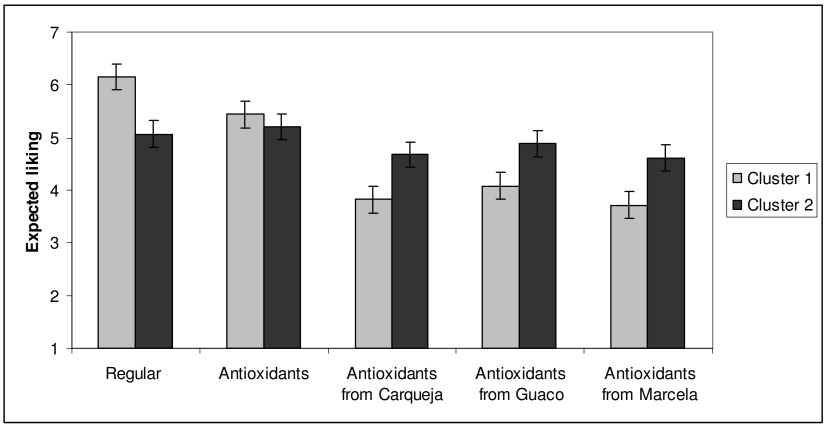
Highly significant differences were found in the mean age of the clusters; Cluster 2 showed a mean age of 43.2 years whereas the mean age for participants in Cluster 1 was 30.7 years. This suggests that older participants were more conscious and interested in health issues and more willing to compromise sensory characteristics for health. This is in agreement with results from previous sections (c.f. Section 2.2 and 2.3) and with those reported by several authors (Poulsen, 1999; de Jong *et al.*, 2003; Urala & Lähteenmäki, 2004; Verbeke, 2005) who stated that the most positive group towards the effects of diet on health and functional foods were middle-aged or elderly consumers. These results are also in agreement with Verbeke (2006) who reported that willingness to compromise on taste increases with age. On the other hand, the clusters did not significantly differ in their gender distribution. Although it has been reported that women are more interested in eating healthily (Steptoe *et al.*, 1995; Roininen *et al.*, 1999; Urala and Lähteenmäki, 2004); this factor did not explain differences between the clusters' behaviour.

The question that arose from these results is if these two groups of participants reacted differently towards information about the source of functional ingredients.

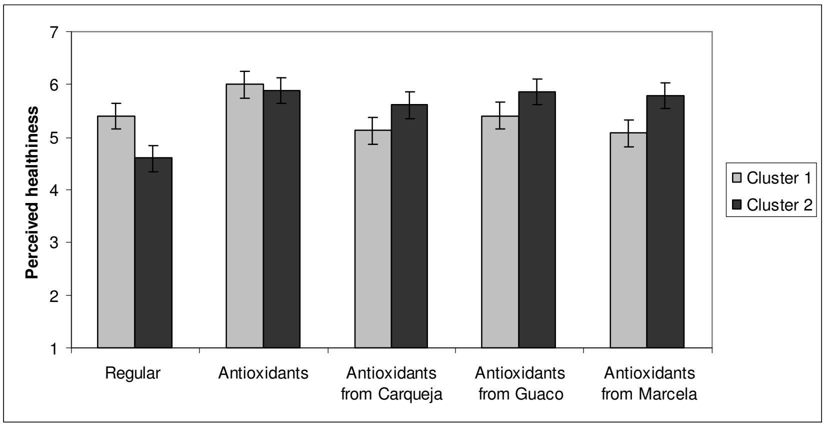
Highly significant ($p<0.001$) differences were found between the clusters' scores for expected liking, perceived healthiness, and willingness to purchase of the evaluated milk dessert concepts. This suggests that consumer attitudes towards health and hedonic characteristics of foods have a high impact on the perception of functional foods.

As shown in Figures 3.7 and 3.8, participants in Cluster 1 decreased their expected liking scores with respect to regular milk desserts when functional ingredients were added. Thus, consumers in Cluster 1 expected that the addition of functional ingredients would change the sensory characteristics of milk desserts, which could limit their acceptance of functional foods. Besides, the addition of information about the source of ingredients caused a greater decrease in their expected liking scores. On the other hand, consumers in Cluster 2 did not decrease their expected liking scores with the addition of functional ingredients to milk desserts, except when fibre from *Pleurotus* was considered. The decrease in expected liking with the addition of fibre from *Pleurotus* mushroom could be attributed to the fact that they are not familiar with this type of mushroom, which strengthens the importance of familiarity when sources of functional foods are considered. Differences in expected liking between the clusters could be explained considering differences in the importance they attribute to hedonic characteristics of foods and in their willingness to compromise taste for health.

(a)



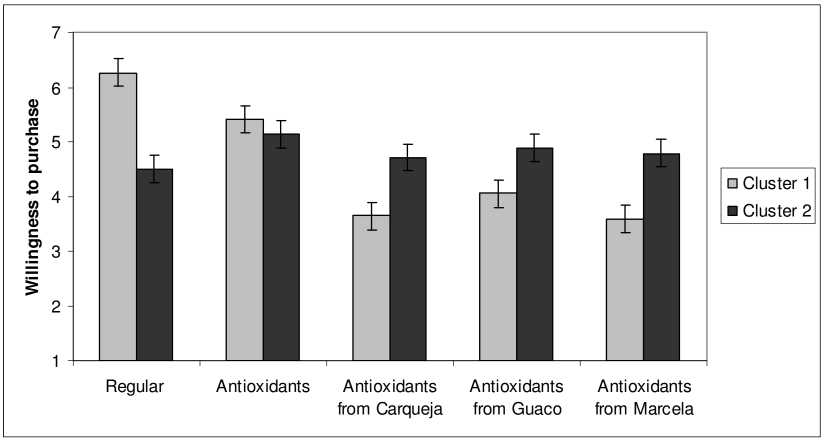
(b)



Vertical lines represent Tukey's honestly significant differences ($p \leq 0.05$)

Figure 3.7. Average scores for **(a)** expected liking and **(b)** perceived healthiness of milk desserts enriched with antioxidants from different sources for consumers in the two identified clusters.

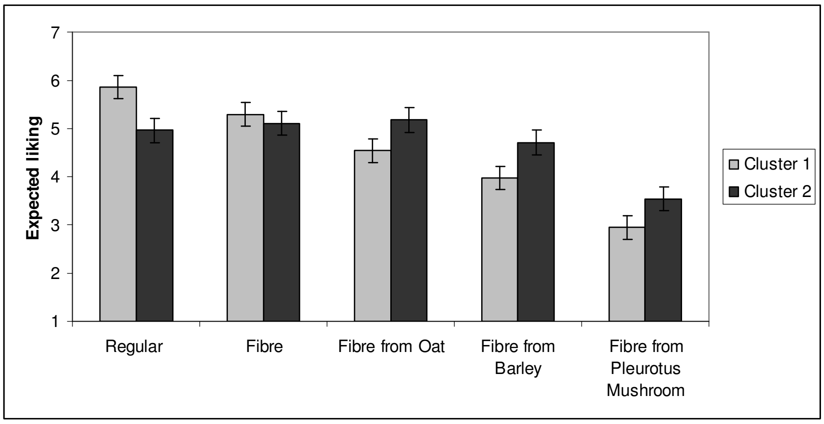
(c)



Vertical lines represent Tukey's honestly significant differences ($p \leq 0.05$)

Figure 3.7 (cont.). Average scores for **(c)** willingness to purchase milk desserts enriched with antioxidants from different sources for consumers in the two identified clusters.

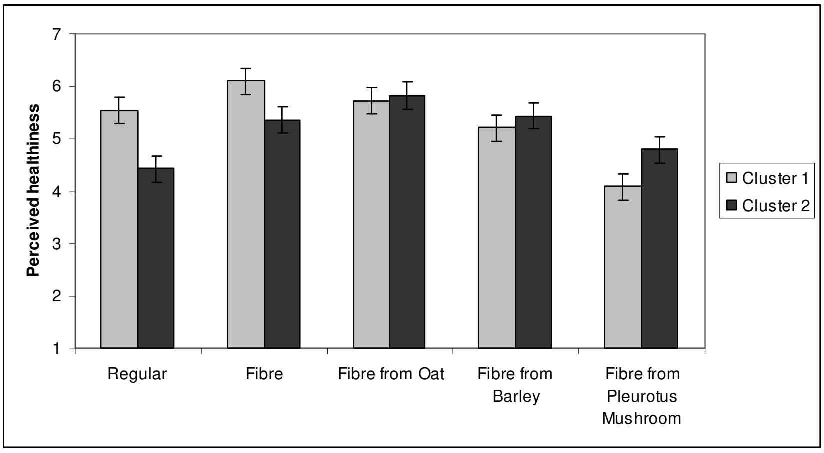
(a)



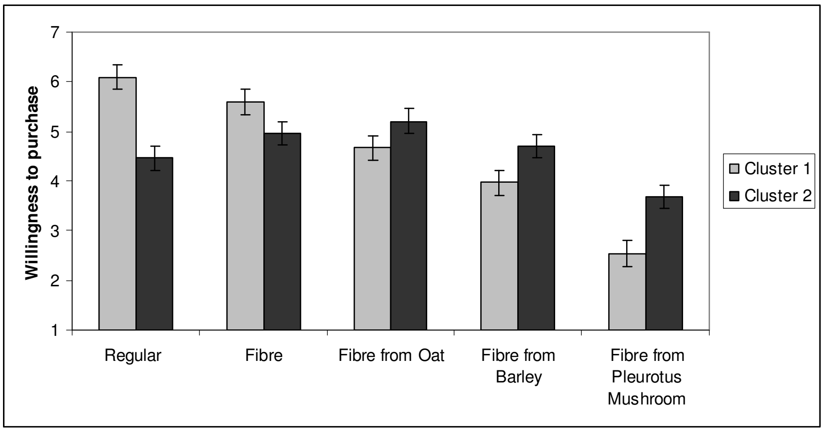
Vertical lines represent Tukey's honestly significant differences ($p \leq 0.05$)

Figure 3.8. Average scores for **(a)** expected liking of milk desserts enriched with fibre from different sources for consumers in the two identified clusters.

(b)



(c)



Vertical lines represent Tukey's honestly significant differences ($p \leq 0.05$)

Figure 3.8 (cont.). Average scores for **(b)** perceived healthiness and **(c)** willingness to purchase milk desserts enriched with fibre from different sources for consumers in the two identified clusters.

The influence of information about the source of functional ingredients on perceived healthiness is also individual dependent. Consumers in Cluster 2 mainly took into account the functional ingredient when judging healthiness and, therefore, the consideration of the source of the ingredient did not change their healthiness scores. On the contrary, consumers in Cluster 1 decreased their healthiness scores when source information was provided. This could be related to the fact that consumers in Cluster 1 were less aware of the health and nutritional properties of the evaluated sources of functional ingredients.

The addition of functional ingredients to milk desserts decreased the willingness to purchase milk desserts for consumers in Cluster 1, which could be explained by the decrease in expected liking. However, the addition of generic functional ingredients increased the willingness to purchase of consumers in Cluster 2. For these consumers, information about the source of antioxidants or the addition of fibre from barley or *Pleurotus* led to a decrease in willingness to purchase, probably because they prefer milk desserts that they do not associate with off-flavours.

As shown in Table 3.16, consumers preferred functional milk desserts that do not include information about the source of functional ingredients. Differences in the clusters' choices were found only for antioxidants, with a higher proportion of consumers in Cluster 2 who chose milk desserts enriched with antioxidants and a lower proportion that chose regular dessert as the product most likely to buy. This is in agreement with the fact that participants in Cluster 2 were more interested in health issues than those in Cluster 1.

Table 3.16. Frequencies in which the five milk dessert concepts for each functional ingredient were chosen as most likely to buy for consumers in Cluster 1 and 2.

Milk dessert	**Percentage of consumers**	
	Cluster 1	**Cluster 2**
Regular	24%	18%
Enriched with fibre	42%	54%
Enriched with fibre from Oat	24%	18%
Enriched with fibre from Barley	8%	0%
Enriched with fibre from *Pleurotus* mushrooms	3%	0%
	$\chi^2 = 6.33$ ns	
Regular	31%	11%
Enriched with antioxidants	47%	75%
Enriched with antioxidants from Marcela	11%	14%
Enriched with antioxidants from Guaco	8%	0%
Enriched with antioxidants from Carqueja	3%	0%
	$\chi^2 = 14.5$ **	

ns – No significant differences (p>0.05), ** - Very significant difference (p<0.001)

The addition of generic functional ingredients was preferred, suggesting that information about the source of functional ingredients might not be included in functional products as it might lead to negative hedonic expectations and, consequently to a decrease in consumer acceptance. The question that arises from these results is if consumers would react similarly when functional ingredients from familiar or well liked products are considered.

Even consumers willing to compromise sensory for health chose functional foods without information about the source of functional ingredients. Therefore, results from the present work sum up to other studies (Drewnowski & Gómez-Carneros, 2000; Gilbert, 2000; Tuorila & Cardello, 2002; Augustin, 2003; Verbeke, 2006) that state that developing functional foods compromising taste for health is not a recommended strategic option.

3.4.3. PARTIAL CONCLUSIONS

Consumers seemed more interested in milk desserts enriched with antioxidants than in milk desserts enriched with fibre. Thus, the former product was selected for the upcoming studies.
Expected liking was the main responsible for the decrease in willingness to purchase, which shows the importance of hedonic expectations on the acceptance of functional foods. Including information about the source of functional ingredients on the labels of functional foods might not be recommended as it might create negative taste expectations.
Willingness to purchase scores were not able to predict consumer choices regarding functional milk desserts, which raise the question of the validity of these scales to study consumer purchase intention.

3.4. GENERAL CONCLUSIONS

Consumers' perception of functional foods seemed to be heterogeneous. Results from the present chapter suggest that willingness to consume functional foods depend on several factors related to both the product and the consumer.
Consumers did not perceive functional foods as a homogeneous category. Their perception was affected by the carrier products and functional ingredients considered. Carrier main effects on

perceived healthiness and willingness to try were larger than those for functional ingredients or interactions, suggesting that products had the largest effect on consumers' perception of healthiness of the evaluated functional foods concepts. Therefore, consumers' perception of the carrier product could override the influence of the functional ingredient.

Dairy products could be interesting carriers for the development of functional foods, due to their healthy image. The addition of functional ingredients to products with an intermediate healthy image resulted in the largest increase in consumers' willingness to try respect to their conventional counterparts. For this reason, milk desserts seemed an interesting carrier product for the development of functional foods. In particular, consumers were interested in the development of functional foods enriched with antioxidants and fibre, showing a slightly larger interest in the former. Therefore, a milk dessert enriched with antioxidants was the functional food selected to be developed in the upcoming studies.

Consumers seemed not much aware of the relationships between consumption of certain compounds and the prevention of diseases, which could limit their interest in functional foods. Therefore, health claims are necessary to assure consumers' awareness of the health benefits of functional foods. The use of health claims increased consumers' interest in consuming functional milk desserts enriched with fibre and antioxidants.

The way in which functional ingredients are declared affected consumers' perception of functional milk desserts. Besides, consumers were more interested in functional milk desserts in which the functional ingredients were declared using common names and without specifying their source.

Socio-demographic variables such as gender and age affected consumers' interest in functional foods. Consumers' attitude towards carrier products, functional ingredients and health claims depended on these variables. Women and old people seemed to be the most positive groups towards functional foods. Consumers' nutritional knowledge and attitudes towards health and sensory characteristics of foods also had a large impact in their perception of functional foods. Therefore, functional foods should be addressed for a specific market segment, aware of the relationship of functional ingredients with health and interested in improving their health status.

CHAPTER 4

EVALUATION OF ANTIOXIDANT EXTRACTS FROM URUGUAYAN NATIVE PLANTS AS FUNCTIONAL INGREDIENTS IN DAIRY PRODUCTS

ABSTRACT

The aim of the present chapter was to evaluate antioxidant extracts from Uruguayan native plants as functional ingredients in dairy products.

The sensory profile, the polyphenolic content and the antioxidant capacity of solvent extracts (water, ethanol and acetone) of three native Uruguayan plants (*Achyrocline satureoides, Baccharis trimera* and *Mikania guaco*) were determined. Native plant and extraction solvent remarkably affected the polyphenolic content, the antioxidant capacity and the sensory profile of the extracts. Water extracts were the most effective radical scavengers and showed the highest polyphenolic concentration. *Mikania guaco* showed the lowest polyphenolic content and the highest intensity of characteristic flavour. Considering their polyphenolic content and sensory characteristics, water extracts from *Baccharis trimera* and *Achyrocline saturoides* were selected as potential functional ingredients.

All the extracts showed a high intensity of bitterness, astringency, and characteristic flavour, which could limit their use as functional ingredients. For this reason, four alternatives to reduce the bitterness, astringency, and characteristic flavour of antioxidant extracts from *Achyrocline satureioides* and *Baccharis trimera* were studied: sucrose, sucralose, polydextrose and milk. All the evaluated alternatives highly significantly ($p<0.001$) reduced the bitterness, astringency and characteristic flavour of the extracts. However, their effectiveness depended on the type and concentration of the antioxidant extract used in the formulation. Milk was the most effective inhibitor of the bitterness and

astringency of *Achyrocline satureioides* extracts; whereas sucrose was the most effective alternative for *Baccharis trimera* extracts. Results suggested that sweetened dairy products could be interesting carriers for the development of functional foods containing polyphenolic-rich antioxidant extracts. In particular, sweetened dairy products flavoured with chocolate could be an appropriate alternative for the development of functional foods containing antioxidant extracts from the Uruguayan native plant *Achyrocline satureioides.*

4.1. INTRODUCTION

Polyphenolic compounds are secondary metabolites of plants (Yilmaz, 2006) that are known to have nutritional as well as medicinal functions in the human body (Walton *et al.*, 1999; Ames *et al.*, 1990; Nair *et al.*, 2007). Polyphenolics from garlic, ginkgo, soybean, tea, grapes and many other fruits and vegetables have dietary importance for humans (Sun & Ho, 2005). Moreover, many herbal medicines used to treat vascular, viral, gastrointestinal, microbial and inflammatory diseases contain plant polyphenols (Haslam, 1989). It is well-known that polyphenolic compounds are responsible for the potential antioxidant activity and radical scavenging capacity of plants (Kanner *et al.*, 1994; Salah *et al.*, 1995; Vinson & Hontz, 1995). Natural antioxidants strengthen the endogenous antioxidant system by reducing oxidative stress and the risk of toxic diseases (Packer, 1996). Radical scavenging antioxidants are particularly important in antioxidative defense to protect cells against the deleterious effects of free radicals on macromolecules such as proteins, lipids, carbohydrates and DNA (Halliwell & Gutteridge, 1984). For these reasons, polyphenols appear as a group of compounds potentially beneficial to human health, and have been claimed to be responsible for the overall physiological health effects of polyphenols-rich plants and foods. In this context, there is increasing interest in the development and use of polyphenolic-rich antioxidant extracts from different plants as functional ingredients.

Achyrocline satureioides (Marcela), *Baccharis trimera* (Carqueja), and *Mikania guaco* (Guaco) are native South-American plants.

They are widespread in Argentina, Brazil, Paraguay and Uruguay. Infusions, decoctions and tinctures of these plants have been used for many years in natural and popular medicine (Filot Da Silva & Langeloh, 1994). These plants have been reported to have a high concentration of polyphenolic compounds (Desmarchelier *et al.*, 1998; De Oliveira *et al.*, 2003), which make them an interesting source of these functional ingredients.

Solvent extraction is frequently used for isolation of polyphenolic compounds (Pinelo *et al.*, 2004; Sun & Ho, 2005; Spigno *et al.*, 2007). The polyphenolic content and antioxidant activity of the extracts depend on the solvent and method of extraction used, due to the different polarities, solubilities and antioxidant potentials of polyphenolic compounds. For this reason, different solvents, such as water, ethanol, methanol, acetone and their mixtures, have been commonly used to obtain antioxidant extracts of plants (Khokhar & Magnusdotti, 2002; Miliauskas *et al.*, 2004; Sun & Ho, 2005; Spigno *et al.,* 2007). The aim of an extraction process is usually to provide extracts with the maximum concentration of target compounds and antioxidant capacity (Spigno *et al.,* 2007). However, the suitability of an antioxidant extract as functional ingredient in food products does not only depend on its antioxidant capacity. The sensory characteristics should also be taken into consideration for commercial applications of antioxidant extracts as functional ingredients. Different extraction methods could yield antioxidant extracts with different sensory characteristics that might affect the sensory profile of the final product. Adding a functional ingredient to a food product in considerable amounts could result in changes in its sensory properties which may lead to a decrease in consumer acceptability and willingness to purchase the product (Tuorila & Cardello, 2002; Urala & Lähteenmäki, 2003). Most published work investigated the influence of solvents on polyphenolic content and antioxidant activity but no study has been found reporting the influence of solvent on the sensory properties of antioxidant extracts.

Polyphenolic compounds are the main responsible for the bitterness and astringency of tea, red wine and several types of fruits (Lesschaeve & Noble, 2005). Therefore, the addition of these compounds to food products could change their sensory characteristics, which may limit the use of polyphenolic extracts from natural plants as functional ingredients in food products. For this reason, alternatives to reduce the bitterness and astringency of polyphenolic extracts should be evaluated. However, the modification of bitterness and astringency of food products is not an easy task (Keast, 2008).

There are basically three types of taste interactions which could be used to reduce the bitter taste of a compound: physicochemical interactions, secondary interactions between one component of the food and the taste receptors/transduction of other component, and central-cognitive mixture suppression (Keast & Breslin, 2002; Keast, 2008). Chemical interactions can change flavour intensity due to the existence of weak attractive forces between different compounds that could make them taste weaker or even become tasteless (Keast & Breslin, 2002). Moreover, central cognitive effects occur when different taste stimuli are mixed together and the perceived intensity of one or more of those stimuli is diminished by the perception of the others (Keast, 2008). One example of this type of effect is the suppression of bitterness with the increase in sweetness.

Astringency is not a taste but a tactile sensation. It is caused by the precipitation of salivary proteins, leading to diminished oral lubrication which is usually described as dryness, puckering and rough-mouthfeel (Bate-Smith, 1954). Astringency perception has been reported to be influenced by ethanol concentration, pH and sweetness (Lesschaeve & Noble, 2005).

The characteristic flavour of medicinal plants is also a potential problem for the development of antioxidant extracts as functional ingredients. Thus, the challenge is to identify food ingredients that reduce the bitterness and astringency of antioxidant extracts and at the same time decrease their characteristic flavour.

The aim of the present chapter was to evaluate solvent extracts of three native Uruguayan plants (*Achyrocline satureoides, Baccharis trímera* and *Mikania guaco*) as functional ingredients. In particular, the specific aims of the present chapter were: **(a)** to determine the sensory profile, the antioxidant activity and the polyphenolic content of three solvent extracts of the three native plants; **(b)** to study different alternatives to reduce the bitterness, astringency, and characteristic flavour of the extracts; and **(c)** to evaluate the suitability of using the antioxidant extracts as functional ingredients in dairy products.

4.2. SENSORY CHARACTERISTICS, POLYPHENOLIC CONTENT AND ANTIOXIDANT CAPACITY OF SOLVENT EXTRACTS OF THREE URUGUAYAN NATIVE PLANTS

4.2.1. MATERIALS AND METHODS

4.2.1.1. Reagents

2,2-diphenyl-1-picryl-hydrazyl (DPPH), Folin-Cioucalteu reagent and gallic acid were obtained from Sigma-Aldrich Co. (Steinheim, Germany). All reagents used were analytical grade.

4.2.1.2. Plant material

Three native Uruguayan plants were considered: *Achiyrocline satureoides*, *Baccharis trimera* and *Mikania guaco.* Dried leaves from the three native plants were obtained from a local retailer (La Botica del Señor, Montevideo, Uruguay). Dried native plants were grounded in a domestic blender immediately before the extractions. Three different samples of each native plant were considered.

4.2.1.3. Solvent extraction

Three solvents were used: acetone, ethanol and distilled water.

Ethanol and acetone extracts were obtained by extraction of each ground dried native plant (10 g) in a Soxhlet extractor for 4 h, using a 15:1 solvent-plant material ratio (v/w). The extract was evaporated to dryness under vacuum at 50ºC in a rotary evaporator. In order to consider both yield and polyphenolic content simultaneously, the dried extracts were redissolved in 20 mL distilled water and filtered. The volume was adjusted to 20 mL after filtration.

For obtaining the aqueous extracts, 10 g of ground dried leaves of each plant were put into a glass jar containing 150 mL distilled water and kept at 90ºC for 1 h with occasional smooth stirring. After this extraction time, the extracts were filtered using Whatman number 1 filter paper. The clear filtrate was concentrated to 20 mL under vacuum at 70ºC in a rotary evaporator.

Extractions were performed in duplicate for each sample of each native plant. Extracts were kept at 5ºC until the evaluations were performed.

4.2.1.4. Beverages

The polyphenolic content and the antioxidant capacity of the Uruguayan native plants under study were compared to those of beverages with well-known antioxidant capacity, such as tea and wine.

Tea (*Camellia sinensis*) bags of finely ground black (Darjeeling Tea, R. Twining and Company Limited, London, U.K.), red (Instituto Botánico La Selva, Montevideo, Uruguay) and green (Instituto Botánico La Selva, Montevideo, Uruguay) tea, as well as Cabernet Sauvignon red wine (Frontera, Concha y Toro, Santiago de Chile, Chile) and Torrontés white wine (Bodegas Pisano, Progreso, Uruguay) were purchased in local supermarkets in Montevideo (Uruguay).

Tea infusions were prepared as specified in the packages. Tea bags (containing 3.0 g of tea leaves) were brewed for 3 min in 250 mL of boiling water. After this time, tea bags were removed and final volume adjusted to 250mL.

4.2.1.5. Polyphenolic content

The total polyphenolic content (TPP) of beverages and extracts was spectrophotometrically determined at 750nm using the Folin–Ciocalteau reagent (Singleton *et al.*, 1965; Taga *et al.*, 1984) and gallic acid as standard.

Briefly, 100 μL of an appropriate dilution of the extracts were added to 2 mL of 2% Na_2CO_3. After 2 min, Folin-Ciocalteu reagent (100 μL) was added to the mixture which was left to stand for 30 min at 20ºC. The absorbance at 750 nm was measured using a Spectronic Genesys 2 spectrophotometer (Spectronic Instruments, Rochester, NY, USA), and compared to gallic acid calibration curves. Results were expressed as gallic acid equivalents (mg/100 mL) using a gallic acid standard curve. All determinations were performed in triplicate and mean values, and their corresponding standard deviations are given.

4.2.1.6. Antioxidant activity

The antioxidant activity of the extracts was determined in terms of their hydrogen donating or radical scavenging ability, using the DPPH radical scavenging method (Brand-Williams *et al.*, 1995). This method is based on the reduction of the stable radical DPPH (2,2-diphenyl-1-picrylhydrazyl) in the presence of antioxidant active substances.

For the analysis, 100 μL of different dilutions of the aqueous solutions of the extracts were placed in a cuvette containing 3.9

mL of a methanolic 60 μM DPPH solution. The reduction of the DPPH radical was measured by monitoring the decrease of absorption at 515 nm using a Spectronic Genesys 2 spectrophotometer (Spectronic Instruments, Rochester, NY, USA), until stable extinction values were obtained (approximately 60 min). The exact DPPH concentration was calculated using a calibration curve. The radical scavenging activity of the extracts was calculated as the amount of DPPH inhibited by the sample as compared to a blank control. Antioxidant capacity was expressed as the volume of extract necessary to decrease 50% the initial DPPH concentration (EC50). All determinations were performed in triplicate and mean values and their corresponding standard deviations are given.

4.2.1.7. Sensory evaluation

The sensory panel consisted of eight assessors, ages ranging from 20 to 45 years old. Assessors were selected following the guidelines of the ISO 8586-1 standard (ISO, 1993). They all had a minimum of 200 h of experience in discrimination and descriptive tests of different foods.

A flavour dilution profile (Jellinek, 1985) of aqueous dilutions of the antioxidant extracts of the three evaluated native plants was performed.

Descriptors were generated separately for the antioxidants extracts of each native plant. Thus, three sessions were performed. In each of these sessions six samples were presented to assessors, who generated the descriptors of a single native plant. Samples corresponded to two aqueous dilutions (1/10 and

1/80) of the three solvent extracts of a native plants. These dilutions were selected based on their polyphenolic content and preliminary studies. First, assessors were asked to generate their individual descriptors using a modified grid method (Damasio & Costell, 1991). By open discussion with the panel leader, assessors agreed on the best descriptors to describe the samples of each native plant. The descriptors used for the sensory profile of the antioxidant extracts were: bitterness, astringency and native plant characteristic flavour (it differed according to the native plant considered). No differences were found in the descriptors used to describe the antioxidant extracts of the three evaluated native plants.

Assessors were trained in the descriptors' evaluation using nine aqueous dilutions of the extracts. The extracts and dilutions used are shown in Table 4.1.

Table 4.1. Descriptions of the nine samples used in the training sessions of the assessors.

Sample	Description
A	1/10 dilution of ethanol extract of *Achiyrocline satureoides*
B	1/80 dilution of ethanol extract of *Baccharis trimera*
C	1/10 dilution of ethanol extract of *Mikania guaco*
D	1/80 dilution of acetone extract of *Achiyrocline satureoides*
E	1/10 dilution of acetone extract of *Baccharis trimera*
F	1/10 dilution of acetone extract of *Mikania guaco*
G	1/10 dilution of water extract of *Achiyrocline satureoides*
H	1/10 dilution of water extract of *Baccharis trimera*
I	1/80 dilution of water extract of *Mikania guaco*

In a first session, assessors were asked to score the bitterness, astringency and characteristic flavour of these samples using 10-cm unstructured scales. Through open discussion with the panel leader assessors agreed on the scores for each of the samples. In successive sessions, the assessors received 5 of the 9 samples, coded with 3-digit numbers. Assessors were asked to evaluate their bitterness, astringency and characteristic flavour, and to score them according to the consensus score. A variation in the scale of ± 1 cm was considered acceptable. A total of ten 20 min sessions were used to train the panel.

The flavour profile of each solvent extract was performed using seven samples. These samples were prepared by diluting the extracts in tap water. The most concentrated sample (Sample 1) was prepared by diluting 1/10 the aqueous dispersion of the extracts with tap water. The other six samples were sequentially diluted with tap water, in a one to one ratio. Table 4.2 shows dilution of the aqueous dilution of the antioxidant extracts corresponding to each of the seven samples.

Table 4.2. Dilutions of the seven evaluated samples of each solvent extract of the three evaluated native plants.

Sample	Dilution
7	1/640
6	1/320
5	1/160
4	1/80
3	1/40
2	1/20
1	1/10

Assessors evaluated two of the three samples of the native plants considered in the study. Duplicate evaluations were performed for each solvent extract of each sample of each native plant. The evaluations were carried out in thirty six sessions. In each session the assessors evaluated seven samples, corresponding to aqueous dilutions of a solvent extract of a native plant. 30 mL of extracts were served in 100 mL plastic glasses at room temperature. Unstructured 10-cm-long scales anchored with ‘nil’ and ‘high’ were used to describe the attribute intensity. The testing was carried out in a sensory laboratory that was designed in accordance with ISO 8589 (ISO, 1988). Evaluations were performed in sensory booths, under red light, temperature control (between 22 and 24ºC) and air circulation.

4.2.1.8. Data analysis

Analysis of variance (ANOVA) was performed on the data from polyphenolic content and antioxidant activity of extract and beverages, considering sample as fixed source of variation. Also, an ANOVA was performed considering native plant, solvent and their interaction as fixed sources of variation.

On data from the sensory profile of solvent extract, an ANOVA was performed considering trained assessor, repetition, native plant, solvent, concentration and the first level interactions native plant * solvent, native plant * concentration and concentration * solvent. When differences were significant, honestly significant differences were calculated using Tukey’s test at 5% significance level.

These analyses were performed using Genstat Discovery Edition 2 (VSN International, Hemel Hempstead, UK).

4.2.2. RESULTS AND DISCUSSION

4.2.2.1. Total polyphenolic content and antioxidant activity

The total polyphenolic (TPP) content of the nine evaluated native plants extracts ranged from 715 to 1450 mg/100mL, as shown in Table 4.3. There was a highly significant effect of the native plant ($p<0.0001$), extraction solvent ($p<0.0001$) and their interaction ($p<0.0001$) on the polyphenolic content. Water extraction yielded significantly more polyphenolic compounds than acetone and ethanol, for the three evaluated native plants. Water extracts of *Baccharis trimera* showed the highest polyphenolic content, followed by *Achyrocline satureoides* and finally *Mikania guaco*. Besides, ethanol extracts of *Baccharis trimera* and *Achyrocline satureoides* showed a higher TPP content than acetone ones. However, the opposite trend was found for *Mikania guaco*. This suggests that the efficiency of the extraction solvent might have depended on the type and polarity of TPP compounds present in the plants.

The free radical scavenging activity of the extracts was determined by the DPPH method. Percent DPPH radical scavenging activity was dependent of the concentration of the extracts. The extract volume necessary to reduce 50% the initial DPPH concentration is shown in Table 4.3.

There was a highly significant effect of the native plant ($p<0.0001$), extraction solvent ($p<0.0001$) and their interaction ($p<0.0001$) on the radical scavenging activity of the extracts. The highest DPPH scavenging activity was shown by the *Baccharis trimera* extracts, in agreement with their highest TPP content. *Baccharis trimera* extracts were followed by *Achyrocline satureoides* regarding their antioxidant activity, whereas *Mikania guaco* extracts were considerably less effective radical scavengers. For the three native plants considered, water extracts contained remarkably higher amounts of radical scavenging compounds, followed by ethanol and finally acetone.

Table 4.3. Total polyphenolic content and antioxidant activity of solvent extracts of native Uruguayan plants, and common beverages.

Sample	Polyphenols (mg/100 mL) [a]	Antioxidant capacity EC_{50} (μL)
Water extract of *Achyrocline satureoides*	1101.7 ± 9.5 [c]	1.21 ± 0.03 [k]
Ethanol extract of *Achyrocline satureoides*	985.8 ± 8.7 [e]	1.89 ± 0.05 [j]
Acetone extract of *Achyrocline satureoides*	907.8 ± 7.2 [f]	2.63 ± 0.07 [h]
Water extract of *Baccharis trimera*	1529 ± 15 [a]	1.10 ± 0.02 [l]
Ethanol extract of *Baccharis trimera*	1453.5 ± 11 [b]	1.24 ± 0.07 [k]
Acetone extract of *Baccharis trimera*	984.0 ± 8.2 [e]	2.77 ± 0.09 [g]
Water extract of *Mikania guaco*	1015.5 ± 9.9 [d]	2.31 ± 0.05 [i]
Ethanol extract of *Mikania guaco*	715.5 ± 5.8 [g]	15.9 ± 0.8 [d]
Acetone extract of *Mikania guaco*	985.8 ± 8.2 [e]	19.0 ± 0.5 [c]
Black Tea	94.2 ± 1.2 [j]	16.1 ± 0.5 [d]
Green Tea	153.8 ± 4.1 [i]	13.3 ± 1.1 [e]
Red Tea	73.7 ± 4.2 [k]	50.1 ± 2.3 [b]
Red Wine	205.5 ± 5.2 [h]	5.0 ± 0.3 [f]
White Wine	39.3 ± 4.2 [l]	62.2 ± 3.1 [a]

Values are presented as mean ± standard deviation. Values within a column with different superscript are significantly different according to Tukey's test ($p \leq 0.05$).
[a] Total polyphenolic content was expressed as gallic acid equivalents.

The radical scavenging activity of the extracts could be related to the content and nature of phenolics. Considering the evaluated antioxidant extracts, there was not a significant correlation between the TPP content of the extracts and their antioxidant activity, expressed as EC50 ($R = -0.514$, $p = 0.154$). Ethanol and acetone extracts from *Mikania guaco* showed a very weak radical scavenging activity, suggesting that their polyphenolic compounds were not very effective radical scavengers. Therefore, the correlation between TPP and EC50 was also calculated after removing these extracts. Without considering these extracts the relationship became significant ($R = -0.81$, $p = 0.029$). This suggests that ethanol and acetone extracts of *Mikania guaco* showed different types of polyphenolic compounds compared to the rest of the extracts. In the case of extracts from *Baccharis trimera* and *Achyrocline satureoides* and water extracts of *Mikania guaco*, differences in their antioxidant capacity could be mainly attributed to differences in their content of polyphenolic compounds.

In order to determine at which concentrations the evaluated native plants extracts should be used in food products, the TPP content and antioxidant capacity of wines and teas were determined and are shown in Table 4.3. The values encountered are similar to those reported in literature (German & Walzem, 2000; Astill, *et al.*, 2001; Bravo *et al.*, 2007). Red wine showed the highest TPP content, approximately 2 g/L, an average value for this type of wine (German & Walzem, 2000; Bravo *et al.*, 2007). Black tea had a lower PP content than green tea, in agreement with results reported by Astill *et al.* (2001) and Bravo *et al.* (2007). Antioxidant capacity of these beverages followed the same trend than TPP content (c.f. Table 4.3).

The concentration at which the antioxidant extracts of Uruguayan native plants should be included in foods could be selected considering the TPP content of the evaluated beverages. Thus, if the antioxidant extracts were diluted 10 - 40 times they would show a TPP content similar to the evaluated beverages. For this reason a 1/10 dilution of the extracts was the first dilution considered for sensory evaluation.

4.2.2.2. Sensory evaluation of aqueous solutions of different solvent extracts of Uruguayan native plants

Bitterness, astringency and characteristic flavour intensities significantly ($p<0.001$) increased with increasing antioxidant extract concentration, until it reached a plateau. Figure 4.1 shows the flavour dilution profile of the ethanol extract of *Baccharis trimera*. A similar trend was found for all evaluated extracts, which showed a high intensity of bitterness, astringency and characteristic flavour, and could compromise their use as functional ingredient in food products. Thus, these results suggest that the sensory characteristics of antioxidant extracts should be taken into account when studying their suitability as functional ingredient in food products.

The influence of the extraction solvent on the sensory profile of the extracts suggests that apart from affecting the yield of polyphenolic compounds, it also influenced the sensory characteristics of an antioxidant extract. As shown in Table 4.4, water extracts were less bitter and astringent than acetone and ethanol extracts. This shows that different solvents from water could also extract other compounds. However, these compounds might have bitter, astringent or metallic flavours. Differences in the sensory profile of antioxidant extracts could also be explained by differences in their composition of polyphenolic compounds. Several authors have recommended the use of methanol, ethanol, acetone or mixtures of these solvents to obtain antioxidant extracts of different plant materials (Miliauskas *et al.*, 2004; Pinelo *et al.*, 2004; Sun & Ho, 2005; Spigno *et al.*, 2007), without considering the influence of these solvents on the sensory characteristics of the extracts.

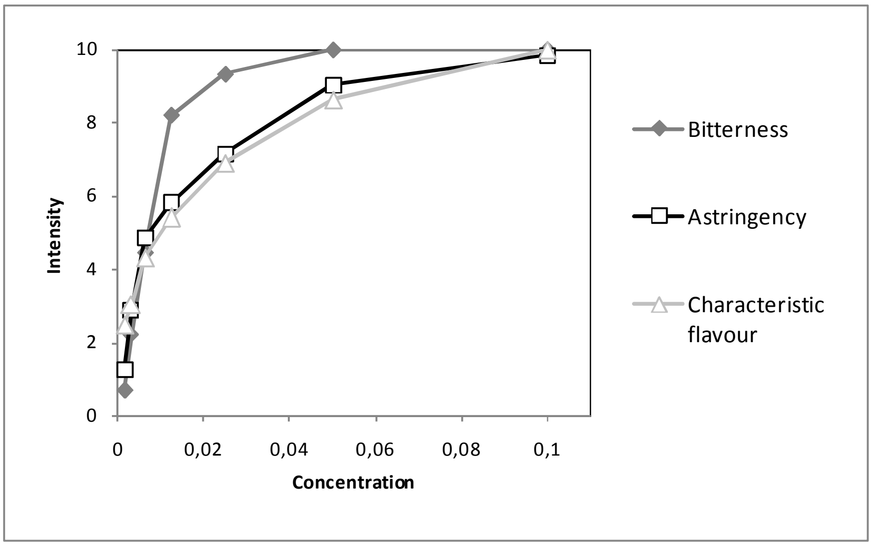


Figure 4.1. Flavor dilution profile of *Baccharis trimera*.ethanol extract.

Extraction solvent and native plant significantly affected ($p<0.001$) the intensity of bitterness, astringency and characteristic flavour of the aqueous dilutions of the extracts (Table 4.4). On the other hand, none of the evaluated interactions showed a significant effect, showing that the variables could be independently considered.

Table 4.4. Effect of the type of solvent and the Uruguayan native plant on the astringency, bitterness and characteristic flavor intensity of aqueous dilutions of antioxidant extracts.

Sample	Mean intensity §		
	Astringency	**Bitterness**	**Characteristic flavour**
Solvent			
Water	4.0^{a}	4.1^{a}	4.9^{a}
Ethanol	5.3^{b}	5.6^{b}	6.2^{b}
Acetone	5.2^{b}	5.8^{b}	5.9^{b}
Native plant			
Achyrocline satureoides	4.0^{a}	4.2^{a}	4.8^{a}
Baccharis trimera	5.4^{c}	5.8^{c}	5.6^{b}
Mikania guaco	4.9^{b}	5.3^{b}	6.5^{c}

Mean values in the same column with different superscript are significantly different according to Tukey's test ($p<0.05$). § evaluated in 10-cm unstructured scales

Extracts from *Achyrocline satureoides* showed the lowest intensity of bitter, astringent and characteristic flavour (Table 4.4). On the other hand, extracts from *Baccharis trimera* were the most bitter and astringent. Although water extracts from this native plant showed the highest TPP content and were the most effective radical scavengers, their high bitterness and astringency could limit their application in food products. Extracts from *Mikania guaco*, which showed the lowest TPP content and antioxidant capacity, showed the highest characteristic flavour intensity for all the evaluated solvents.

Polyphenolic compounds are the main responsible for the bitterness and astringency of vegetables (Lesschaeve & Noble, 2005). However, their bitterness and astringency does not depend only on their concentration but also on their chemical structure. Differences in the degree of polymerization, the identity of the monomeric units, the bond location and the degree of esterification of polyphenolic compounds have been reported to markedly affect their bitterness and astringency (Robichaud & Noble, 1990; Thorngate & Noble, 1995; Kallithraka *et al.*, 1997; Peleg *et al.*, 1999; Lesschaeve & Noble, 2005). In the present study TPP of the extracts was not significantly correlated with the average bitterness (R=0.367) and astringency (R=0.356) intensities throughout concentrations of their aqueous dilutions. Therefore, differences between the bitterness and astringency of the extracts could not be explained considering differences in their TPP. This suggests that differences in the sensory characteristics of the extracts might be explained by differences in the composition of polyphenolic compounds instead of TPP content. Moreover, apart from causing differences in TPP content, the evaluated solvents might have also introduced differences in the composition of polyphenolic compounds of the extracts or in the concentration of other compounds. Further research is necessary in order to relate the sensory characteristics of the extracts with the composition of polyphenolic compounds.

On the other hand, the characteristic flavour of the extracts was not significantly correlated to their TPP content (R=0.05), as expected since polyphenolic compounds are not responsible for the characteristic flavour of the evaluated native plants.

Results from the present section indicate that the selection of antioxidant extracts to be used as functional ingredients in food products should be based on a compromise between their antioxidant capacity and sensory characteristics.

4.2.3. PARTIAL CONCLUSIONS

Both native plant and solvent showed a highly significant effect on the polyphenolic content, the antioxidant capacity and the sensory profile of the antioxidant extracts.

Water extracts of *Baccharis trimera* and *Achyrocline saturoides* showed the highest polyphenolic content and antioxidant capacity. Although these extracts could be regarded as potential functional ingredients, their high bitterness and astringency could limit their application in food products. Thus, further research is needed to evaluate their possible applications and to study alternatives to mask the undesired flavours of the extracts.

Baccharis trimera extracts showed the highest antioxidant capacity but they also were the most bitter and astringent. Thus, when optimizing the extraction of antioxidant compounds from plants, apart from studying the influence of extraction solvents on yield, polyphenolic content and antioxidant capacity, the sensory characteristics of the antioxidant extracts should also be taken into account.

On the other hand, *Mikania guaco* showed the lowest polyphenolic content and the highest intensity of characteristic flavour. Thus, this native plant was not further studied. Considering their polyphenolic content and sensory characteristics, water extracts from *Baccharis trimera* and *Achyrocline saturoides* were considered as potential functional ingredients for the development of a functional food product.

4.3. ALTERNATIVES TO REDUCE THE BITTERNESS, ASTRINGENCY AND CHARACTERISTIC FLAVOUR OF ANTIOXIDANT EXTRACTS

4.3.1. MATERIALS AND METHODS

4.3.1.1. Plant material and extraction conditions

According to the results of Section 4.2, only water extracts from *Achyrocline satureioides* and *Baccharis trimera* were considered. Dried leaves from both native plants were obtained from a local retailer (La Botica del Señor, Montevideo, Uruguay). Water extracts of these two plants were obtained as described in 4.2.1.3.

4.3.1.2. Antioxidant extracts preparation

The total polyphenolic content (TPP) content of the extracts was determined using the Folin–Ciocalteau reagent (Singleton *et al.*, 1984), as described in 4.2.1.5.

Two extract concentrations were considered for each native plant, which corresponded to the following polyphenolic contents: 780 mg/L (concentration A) and 390 mg/L (concentration B).

4.3.1.3. Trained assessors' panel

The sensory panel consisted of eight assessors, aged from 20 to 45 years old. Assessors were selected and trained following the guidelines of the ISO (1993) standard. They all had a minimum of 200 h of experience in discrimination and descriptive tests of different food products and had a minimum of four months experience in the evaluation of aqueous solutions of antioxidant extracts from Uruguayan native plants.

4.3.1.4. Effect of different inhibitors on the bitterness and astringency

Four bitterness and astringency inhibitors were evaluated: sucrose, sucralose, polydextrose and milk.

The most common way of reducing bitterness is by increasing the sweetness. Thus, a caloric (commercial sucrose) and a noncaloric sweetener (sucralose) were considered in the study.

- *Sucrose evaluation*

Two sucrose concentrations were considered: 8 and 12% (w/v). Concentrations were selected considering those commonly used in milk products such as yogurts (Vickers *et al.*, 2001; Ares *et al.*, 2007) and milk desserts (Elmore *et al.*, 1999; de Wijk *et al.*, 2006; Tárrega & Costell, 2006). The two antioxidant extracts, with two concentrations (A and B) each, were evaluated in water and in water containing sucrose; which yielded a total of six samples for each antioxidant extract. Evaluations were performed in duplicate, in separate sessions for each antioxidant extract. A total of four sessions on separate days were carried out.

Solutions (10 mL) were presented in plastic 60 mL containers at room temperature coded with 3-digit random numbers. Assessors evaluated bitterness, astringency, sweetness and characteristic flavor intensity using unstructured 10-cm-line scales anchored with ‘nil’ and ‘high’. The samples were presented in balanced random order. The assessors were instructed to pour the whole sample in their mouth, hold it for 3 seconds and rate the bitterness, astringency, sweetness, and native plant characteristic flavour of the solution. Assessors rinsed their mouths with water four times during a 2 minute interval between samples. The testing was carried out in a sensory laboratory designed in accordance with ISO 8589 (ISO, 1988). Evaluations were performed in sensory booths under red light, temperature control (between 22 and 24ºC) and air circulation.

- *Sucralose evaluation*

Two Splenda® (McNeil Nutritionals, LCC, Washington, USA) concentrations were used: 1.08 and 1.92% (w/v), which corresponded to sucralose concentrations of 0.013 and 0.023% respectively. Concentrations were selected to have the same sweetness intensity of the sucrose solutions and were determined using paired-comparison test. The two antioxidant extract concentrations (A and B) were evaluated in water and in water containing sucralose, which yielded a total of six samples. The testing protocol was the same as that described for sucrose.

- *Polydextrose evaluation*

Polydextrose is a polysaccharide commonly used as fat-mimetic in low-fat dairy products and it is also used to replace sugars in various desserts (Mitchell, 1996; Roland *et al.*, 1999). Polydextrose has been reported to mask unpleasant flavors by its ability to interact by polar, hydrogen bonds or dipole-dipole interactions (Plug & Haring, 1993). Furthermore, polydextrose is partially metabolized in the intestinal tract and therefore could be regarded as fibre and probiotic (Mitchell, 2004). Litesse® two (Danisco Sweeteners Ltd, Surrey, United Kingdom) was used in the study.

Two Litesse® concentrations were selected considering Argentinean requirements to label a food product as source of fibre and rich in fiber: 1.5 and 3% respectively (Administración Nacional de Medicamentos, Alimentos y Tecnología Médica, 2007). The evaluation followed the same procedures previously described.

- *Milk evaluation*

Fat emulsions have been reported to inhibit the bitterness of quinine (Metcalf & Vickers, 2002). Particularly, milk was reported by Keast (2008) as an effective inhibitor of the bitterness of caffeine. Milk with two fat concentrations (3.2 and 0%) was used in the present study. Whole and skimmed powdered milk were prepared following the manufacturer’s instructions. Powdered milk was reconstituted using distilled water to a final solids concentration of 13%. Antioxidant extracts were evaluated in water, whole (3.2% fat) and skimmed (0% fat) milk following the same testing protocol previously presented, but instead of sweetness, milky flavor was evaluated.

4.3.1.5. Data analysis

A three-way ANOVA with interactions was performed on sensory data for each antioxidant extract and inhibitor. Extract concentration, inhibitor concentration, assessor and their first order interactions were considered as fixed sources of variation. When differences were significant, honestly significant differences were calculated using Tukey's test at 5% significance level. These analyses were performed using Genstat Discovery Edition 2 (VSN International, Hemel Hempstead, UK).

4.3.2. RESULTS

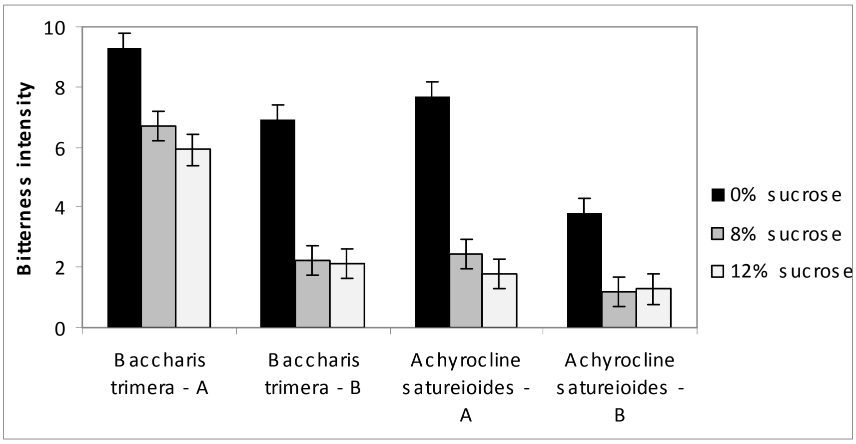
4.3.2.1. Influence of sucrose on bitterness, astringency and characteristic flavour of antioxidant extracts

According to the ANOVA, sucrose caused a highly significant ($p<0.001$) decrease in the bitterness, astringency and characteristic flavour of the antioxidant extracts.

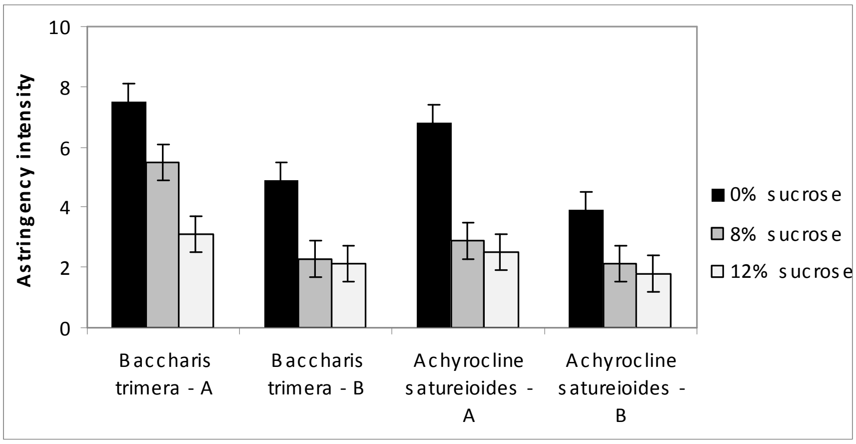
As shown in Figure 4.2, the addition of 8% sucrose caused a highly significant ($p<0.05$) decrease in the bitterness and astringency of the extracts. However, an increase from 8 to 12% in sucrose concentration did not result in a further decrease in the bitterness of the extracts. This also occurred for the astringency of *Achyrolicline satureioides*. For *Baccharis trimera* extracts at concentration A, the astringency was significantly ($p<0.05$) reduced when sucrose concentration was increased from 8 to 12%.

The decrease in characteristic flavour was only significant when the highest concentration of extracts was considered (concentration A). When the extracts were evaluated at concentration B the addition of sucrose did not result in a significant decrease in characteristic flavour, except for the addition of 12% sucrose to extracts from *Baccharis trimera* (c.f. Figure 4.2).

(a)



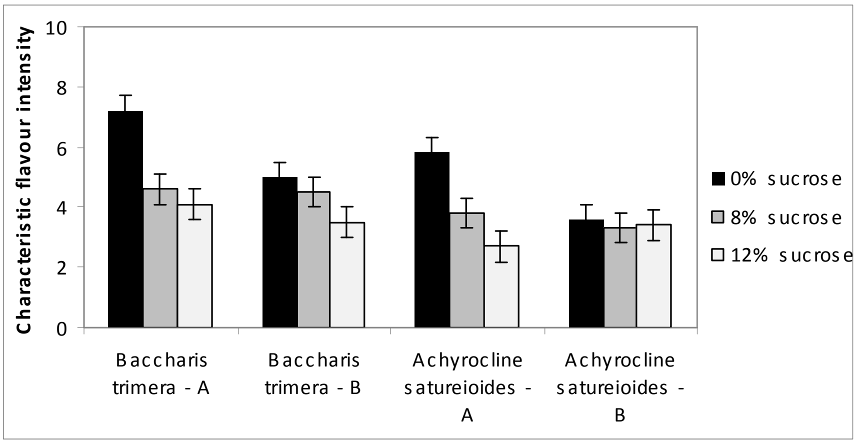
(b)



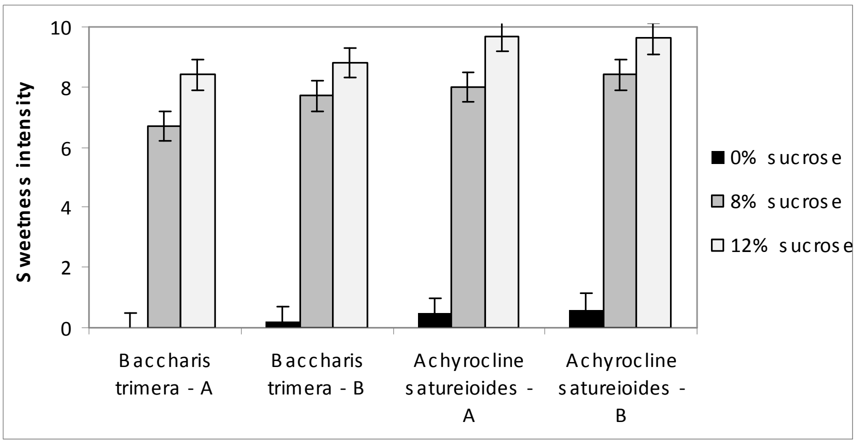
Vertical lines represent Tukey's honestly significant differences ($p<0.05$). Extract concentrations A and B corresponded to a concentration of polyphenolic compounds of 780 mg/L and 390 mg/L respectively.

Figure 4.2. Influence of sucrose on **(a)** bitterness and **(b)** astringency of antioxidant extracts from *Baccharis trimera* and *Achyrocline satureioides* at two different concentrations (A and B).

(c)



(d)



Vertical lines represent Tukey's honestly significant differences ($p<0.05$). Extract concentrations A and B corresponded to a concentration of polyphenolic compounds of 780 mg/L and 390 mg/L respectively.

Figure 4.2 (cont). Influence of sucrose on **(c)** characteristic flavour and **(d)** sweetness of antioxidant extracts from *Baccharis trimera* and *Achyrocline satureioides* at two different concentrations (A and B).

As shown in Figure 4.2, the effectiveness of sucrose in reducing the bitterness, astringency and characteristic flavour of the extracts also depended on the extract. Sucrose was more effective for *Achyrocline satureioides* extracts.

The *Baccharis trimera* extracts were less sweet than the extracts from *Achyrocline satureioides* (c.f. Figure 4.2), which could be attributed to the higher bitterness of the former. Further research is needed to investigate which chemical differences between the extracts may be responsible for their different bitter magnitudes and the differential influence of sweetness.

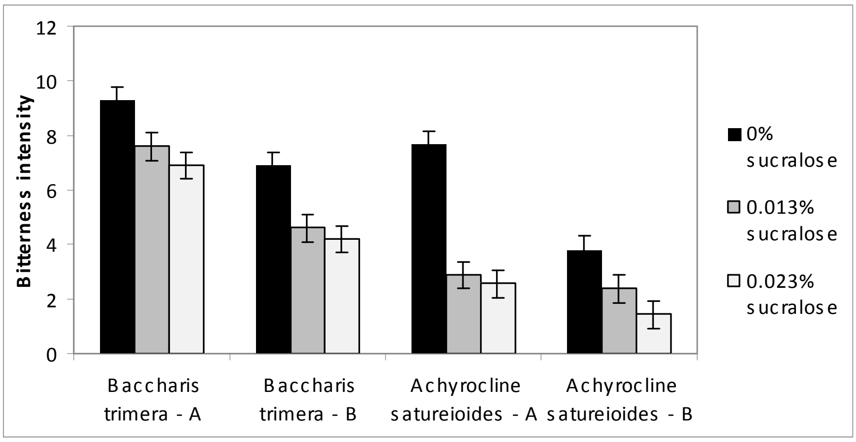
4.3.2.2. Influence of sucralose on bitterness, astringency and characteristic flavour of antioxidant extracts

ANOVA revealed that the addition of sucralose caused a highly significant ($p<0.001$) decrease in the bitterness, astringency and characteristic flavour of the antioxidant extracts. However, as shown in Figure 4.3, an increase of sucralose concentration from 0.013 to 0.023% did not result in a significant decrease in bitterness, astringency or characteristic flavour of the extracts.

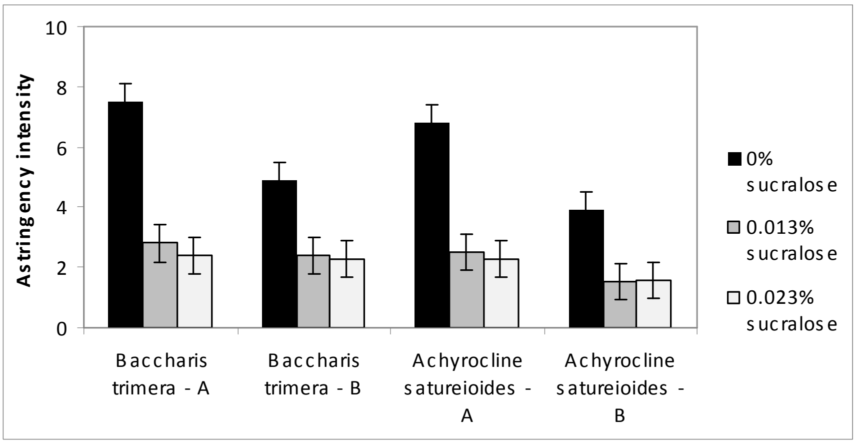
As for sucrose, the effectiveness of sucralose in reducing the bitterness, astringency and characteristic flavour of the extracts depended on the extract considered (c.f. Figure 4.3), being more effective in *Achyrocline satureioides*. The effect of sucralose in reducing bitterness and characteristic flavour was smaller than that of sucrose.

Although sucralose solutions presented equivalent sweetness of sucrose solutions, the extracts with sucralose were perceived less sweet than those with sucrose, as shown in Figures 4.2 and 4.3.

(a)



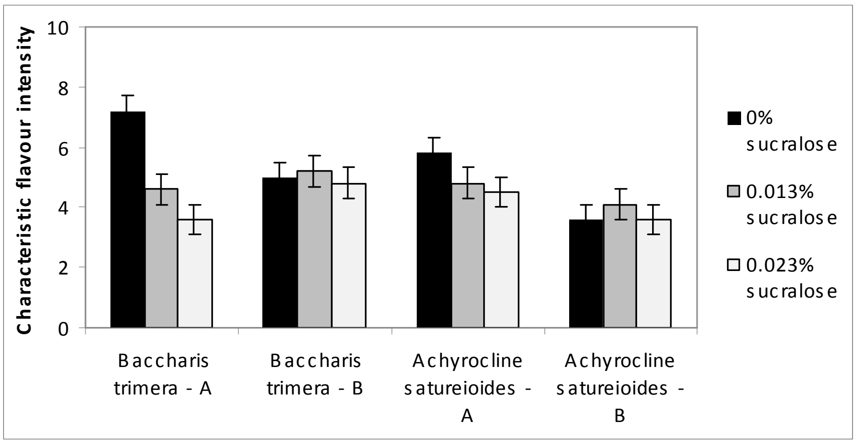
(b)



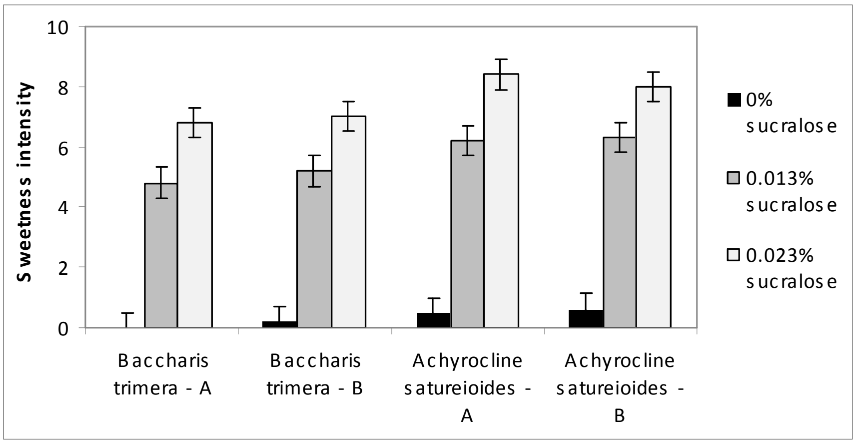
Vertical lines represent Tukey's honestly significant differences ($p<0.05$). Extract concentrations A and B corresponded to a concentration of polyphenolic compounds of 780 mg/L and 390 mg/L respectively.

Figure 4.3. Influence of sucralose on **(a)** bitterness and **(b)** astringency of antioxidant extracts from *Baccharis trimera* and *Achyrocline satureioides* at two different concentrations (A and B).

(c)



(d)



Vertical lines represent Tukey's honestly significant differences ($p<0.05$). Extract concentrations A and B corresponded to a concentration of polyphenolic compounds of 780 mg/L and 390 mg/L respectively.

Figure 4.3 (cont.). Influence of sucralose on **(c)** characteristic flavour and **(d)** sweetness of antioxidant extracts from *Baccharis trimera* and *Achyrocline satureioides* at two different concentrations (A and B).

This could be explained considering that the sweetness of sucralose was masked by bitterness to a larger extent than that of sucrose, or because of the bitter taste of sucralose.

4.3.2.3. Influence of polydextrose on bitterness, astringency and characteristic flavour of antioxidant extracts

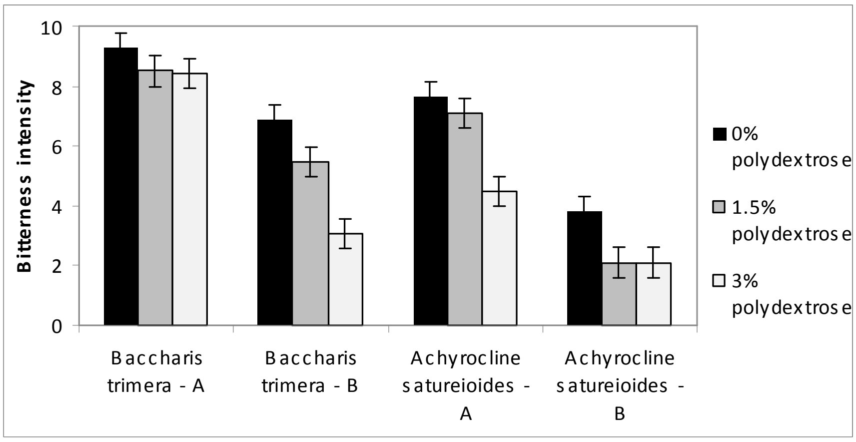
The effectiveness of polydextrose in reducing the bitterness of the extracts depended on their type and concentration, as shown in Figure 4.4. Polydextrose did not significantly decrease the bitterness of *Baccharis trimera* at concentration A. Regarding extracts from *Achyrocline satureioides* at concentration A, only 3% significantly ($p<0.05$) decreased their bitterness. When the antioxidant extracts were evaluated at concentration B, both 1.5 and 3% polydextrose significantly decreased bitterness ($p<0.05$).

The addition of 1.5% polydextrose only significantly reduced the astringency of *Achyrocline satureioides* extracts at concentration A. Besides, the addition of 3% polydextrose resulted in a significant ($p<0.05$) decrease of the astringency of all the evaluated extracts.

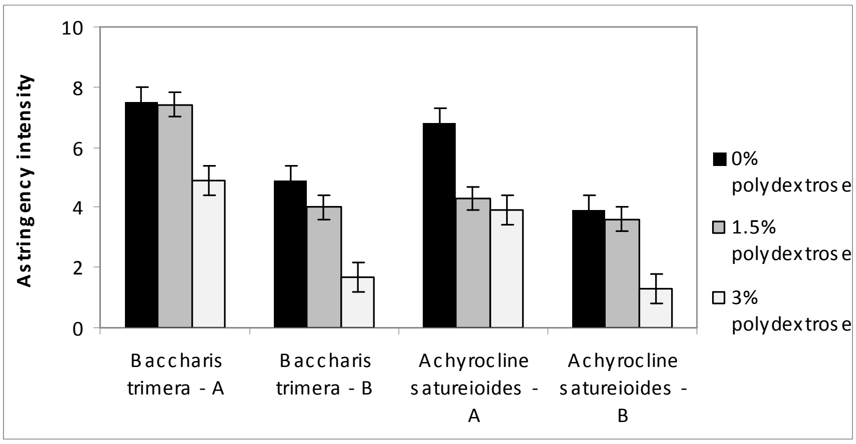
Furthermore, polydextrose only significantly reduced the characteristic flavour of *Achyrocline satureoides* at the highest concentration and of *Baccharis trimera* at the lowest concentration, as shown in Figure 4.4.

The effectiveness of polydextrose in decreasing the bitterness, astringency and characteristic flavour of the extracts was lower than that of sucrose or sucralose

(a)



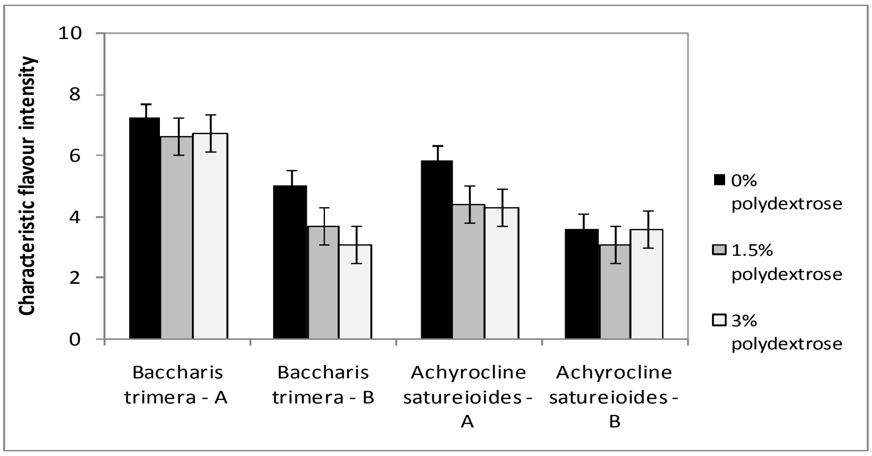
(b)



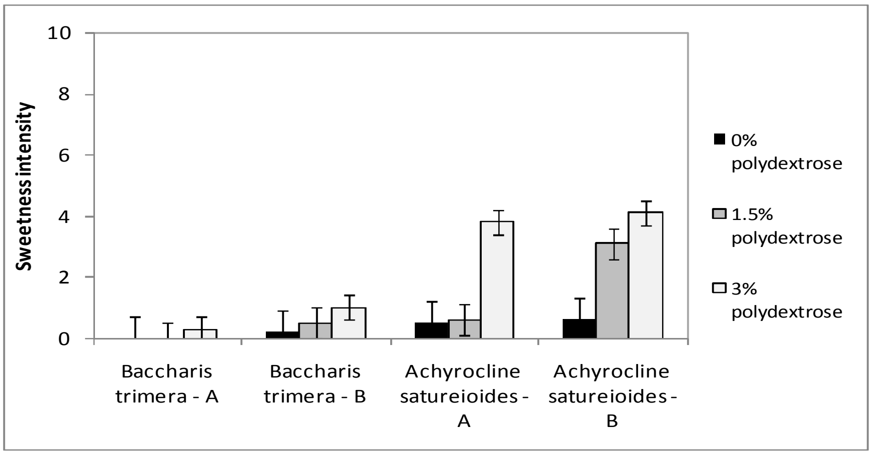
Vertical lines represent Tukey's honestly significant differences ($p<0.05$). Extract concentrations A and B corresponded to a concentration of polyphenolic compounds of 780 mg/L and 390 mg/L respectively.

Figure 4.4. Influence of polydextrose on **(a)** bitterness and **(b)** astringency of antioxidant extracts from *Baccharis trimera* and *Achyrocline satureioides* at two different concentrations (A and B).

(c)



(d)



Vertical lines represent Tukey's honestly significant differences ($p<0.05$). Extract concentrations A and B corresponded to a concentration of polyphenolic compounds of 780 mg/L and 390 mg/L respectively.

Figure 4.4 (cont.). Influence of polydextrose on **(c)** characteristic flavour and **(d)** sweetness of antioxidant extracts from *Baccharis trimera* and *Achyrocline satureioides* at two different concentrations (A and B).

The addition of polydextrose to the antioxidant extracts only slightly increased the sweetness of the extracts (c.f. Figure 4.4). In the case of *Baccharis trimera* extracts, the increase in sweetness was almost unperceivable.

4.3.2.4. Influence of milk on bitterness, astringency and characteristic flavour of antioxidant extracts

Milk highly significantly ($p<0.01$) reduced the bitterness and astringency of extracts from *Achyrocline satureioides*.

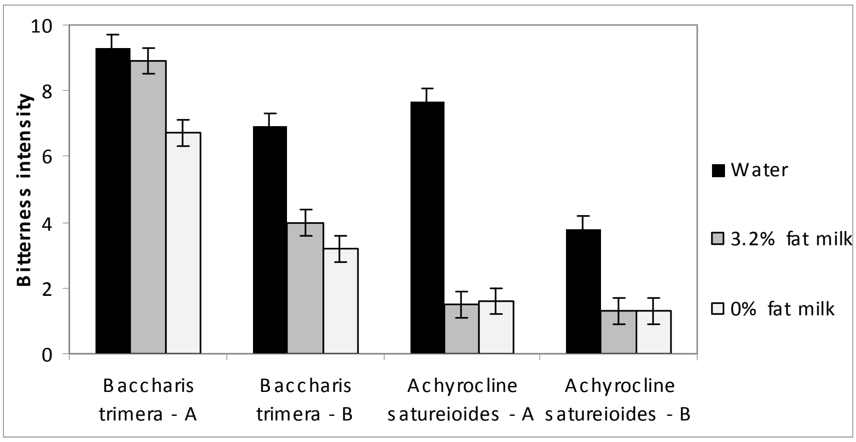
No significant differences ($p>0.05$) were found in bitterness and astringency of *Achyrocline satureioides* extracts, regardless of the milk fat content (Figure 4.5). As shown in Figures 4.2-4.5, 0% and 3.2% fat milk were the most effective inhibitors of the bitterness and astringency of extracts from *Achyrocline satureoides*.

On the other hand, the influence of milk on the bitterness of *Baccharis trimera* extracts depended on the concentration, as shown in Figure 4.5. Whereas 3.2% fat milk did not significantly reduced the bitterness of *Baccharis trimera* extracts at concentration A, it caused a significant ($p<0.05$) bitterness decrease at concentration B. When 0% fat milk was considered, bitterness reduction was 28% and 42% for *Baccharis trimera* extracts at concentrations A and B, respectively.

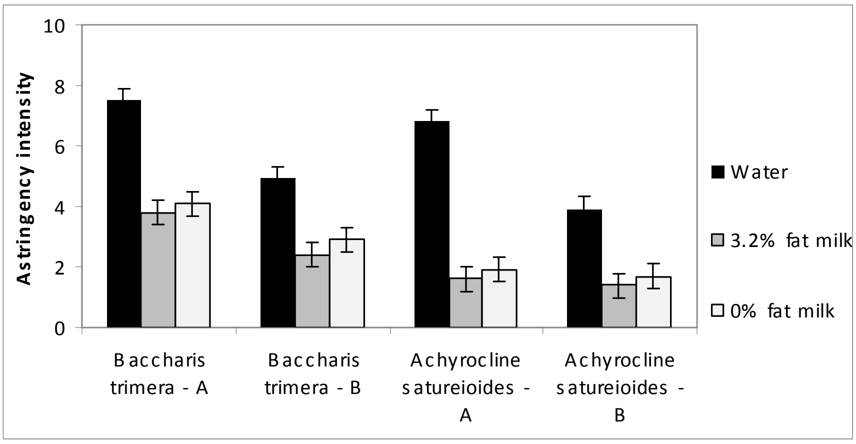
The influence of milk fat content on bitterness reduction depended on the type of extract and it worked better with *Achyrocline satureoides* than with *Baccharis trimera*.

Both 0% and 3.2% fat milk were very effective in reducing the astringency of *Achyrocline satureoides* and *Baccharis trimera* extracts, as shown in Figure 4.5. No significant differences (p>0.05) were found in astringency intensity regarding the milk fat content.

(a)



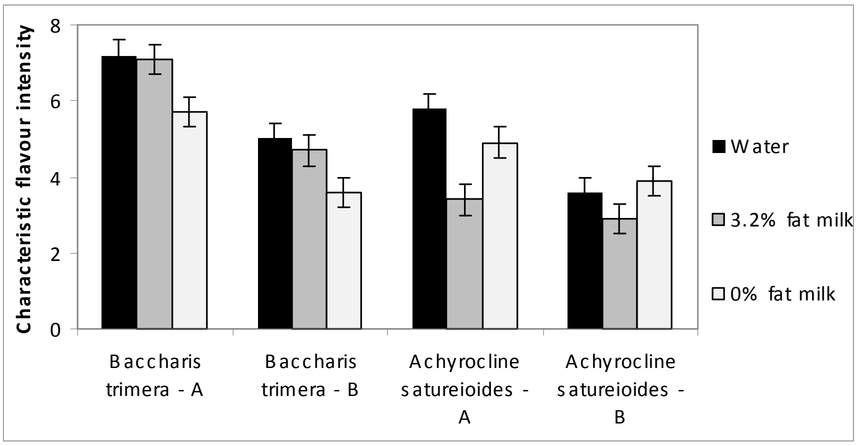
(b)



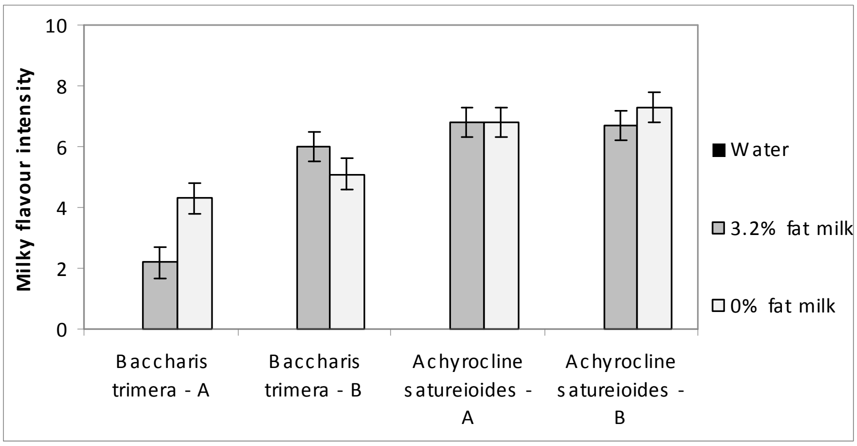
Vertical lines represent Tukey's honestly significant differences ($p<0.05$). Extract concentrations A and B corresponded to a concentration of polyphenolic compounds of 780 mg/L and 390 mg/L respectively.

Figure 4.5. Influence of milk (3.2% and 0% fat) on **(a)** bitterness and **(b)** astringency of antioxidant extracts from *Baccharis trimera* and *Achyrocline satureioides* at two different concentrations (A and B).

(c)



(d)



Vertical lines represent Tukey's honestly significant differences ($p<0.05$). Extract concentrations A and B corresponded to a concentration of polyphenolic compounds of 780 mg/L and 390 mg/L respectively.

Figure 4.5. (cont.). Influence of milk (3.2% and 0% fat) on **(c)** characteristic flavour and **(d)** sweetness of antioxidant extracts from *Baccharis trimera* and *Achyrocline satureioides* at two different concentrations (A and B).

The ability of milk to mask the characteristic flavour of the extracts depended on the type and concentration of the antioxidant extract and on the type of milk considered, as shown in Figure 4.5. Skimmed milk was more effective than whole milk in reducing the characteristic flavour of *Baccharis trimera*. On the other hand, the opposite was found for extracts from *Achyrocline saturieoides*. Whole milk reduced 41.9% and 19.4% the characteristic flavour of extracts from *Achyrocline saturieoides* at concentrations A and B respectively; whereas skimmed milk only reduced 15% the characteristic flavour in the highest extract concentration.

Milky flavour was more intense in *Achyrocline saturieoides* than in *Baccharis trimera* (c.f. Figure 4.5). This could be explained by the higher bitterness, astringency and characteristic flavour of *Baccharis trimera* extracts, which could have reduced milky flavour perception.

4.3.3. DISCUSSION

Sweetness proved to be an effective alternative for reducing the bitterness, astringency and characteristic flavour of the evaluated extracts. The reduction of bitterness could be explained considering the mutual suppression of bitterness and sweetness due to a central cognitive effect (Calviño & Garrido, 1991; Keast & Breslin, 2002). The reduction of bitterness depended on the type and concentration of antioxidant extracts being considered. Therefore, the effectiveness of these alternatives might be influenced by the type, structure and concentration of polyphenolic compounds.

The decrease of astringency as a result of increasing sweetness was in agreement with results reported by Ishikawa & Noble (1995) and Lyman & Green (1990). The inhibition of astringency due to an increase in sweetness could be explained by an increase in salivary volume and the lubrication characteristics of sucrose solutions (Lyman & Green, 1990).

Although sucrose and sucralose solutions presented equal sweetness, the reduction of bitterness astringency and characteristic flavour achieved by these sweeteners was different. Further research is necessary to study these differences.

Polydextrose also decreased the bitterness, astringency and characteristic flavour of the extracts. This effect could be attributed to its increased viscosity and to the possibility of making hydrogen bonds with polyphenols (Plug & Haring, 1993), which could diminish the interaction of polyphenols with taste receptors or salivary proteins. The mechanisms responsible for the reduction of bitterness and astringency by polydextrose also need further investigation. Although polydextrose was the least effective inhibitor of bitterness and astringency on the antioxidant extracts, it only caused a slight increase of sweetness. This could be interesting if inhibitors of bitterness or astringency that only slightly modify sweet taste of a food product are needed. Besides, the other advantage of polydextrose is the fact that it is a functional ingredient, and could be declared as soluble fibre apart from acting as inhibitor of bitterness and astringency. Therefore, polydextrose seems to be an interesting ingredient to mask unpleasant flavours in functional food products.

Milk, both 0% and 3.2% fat, was very effective in reducing the bitterness of *Achyrocline satureioides* extracts and the astringency of both *Achyrocline satureioides* and *Baccharis trimera* extracts. The reduction of bitterness was in agreement with results reported by Keast (2008). One of the mechanisms suggested by this author was the migration of polyphenolic compounds to the fat phase. However, this might not be the case in the present study as 0% and 3.2% fat milk showed similar bitterness reduction. Therefore, the effect could be attributed to milk proteins, which may complex with polyphenolic compounds yielding insoluble or at least compounds incapable of interacting with the taste receptors (Brown & Wright, 1963; Keast, 2008). This mechanism could also be responsible for the reduction of astringency by milk, as polyphenolic compounds that form complexes with milk proteins would be unable to interact with salivary proteins. However, no precipitation was observed in the present study. Further research is needed to understand the mechanism responsible for the reduction of bitterness and astringency by milk. Moreover, studies should be carried out to evaluate if the complexes formed between milk proteins and polyphenolic compounds affect their bioavailability in milk products.

The four ingredients (sugar, sucralose, polydextrose and milk) were less effective in reducing the characteristic flavour of the extracts than their bitterness and astringency. An increase in sweetness was the most effective alternative to reduce the characteristic flavour of the antioxidant extracts, achieving a maximum reduction of 50%. Therefore, other ingredients to reduce their characteristic flavour, such as flavourings, should be studied.

4.3.4. PARTIAL CONCLUSIONS

All the evaluated alternatives were effective in reducing the bitterness, astringency and characteristic flavour of antioxidant extracts from Uruguayan native plants. The effectiveness of different alternatives for reducing the bitterness and astringency of polyphenolic compounds depended on the type and concentration of antioxidant extract considered; suggesting the importance of studying the effectiveness of different alternatives for each specific application.

Polydextrose introduced the smallest modifications in the sensory profile of the solutions, as it only slightly increased their sweetness. Furthermore, it could be declared as functional ingredient,

The effectiveness of milk and sucrose in reducing the bitterness and astringency of the extracts suggests that sweetened dairy products could be interesting carriers for the development of functional foods containing polyphenolic-rich antioxidant extracts. However, further studies should be carried out to reduce the characteristic flavour of the extracts, in order to determine their suitability as functional ingredients in this type of products.

Considering that *Achyrocline satureioides* extracts showed a lower bitterness, astringency and characteristic flavour intensity than extracts from *Baccharis trimera*, only the former extract was considered as potential functional ingredient in the next sections of the present thesis.

4.4. EFFECT OF DIFFERENT INGREDIENTS ON THE SENSORY CHARACTERISTICS OF ANTIOXIDANT EXTRACTS IN MILK

4.4.1. MATERIALS AND METHODS

4.4.1.1. Antioxidant extract

A water extract from *Achyrocline satureioides* was obtained as described in 4.2.1.3. The total polyphenolic content (TPP) of the extract was determined using the Folin–Ciocalteau reagent (Singleton *et al.*, 1984) (c.f. Section 4.2.1.5).

4.4.1.2. Stimuli

Commercial powdered milk (26% fat) and skimmed powdered milk (0% fat) were used. Powdered milk was reconstituted using distilled water to a final solids concentration of 13%, according to the manufacturer's instructions.

The antioxidant extract from *Achyrocline satureioides* was diluted in whole (3.2% fat) or skimmed (0% fat) milk, to a final concentration of 780 mg/L of polyphenolic compounds. This concentration corresponded to the highest considered in Section 4.4.3.

4.4.1.3. Trained assessors' panel

The sensory panel consisted of eight assessors, ages ranging from 20 to 45 years old. Assessors were selected and trained following the guidelines of the ISO (1993) standard. They all had a minimum of 200 h of experience in discrimination and descriptive tests of different food products and had a minimum of four months experience in the evaluation of aqueous solutions of antioxidant extracts from Uruguayan native plants.

4.4.1.4. Influence of sucrose, polydextrose and flavourings in the sensory attributes of antioxidant extract in whole and skimmed milk

The antioxidant extract was evaluated in whole and skimmed milk with and without 8% sucrose, which yielded a total of four samples.

For the polydextrose study, the antioxidant extract was evaluated in whole and skimmed milk containing 0, 1.5 and 3% polydextrose (Litesse® two), which yielded a total of six samples. The same concentrations of poydextrose were studied with 0% and 8% of sucrose.

The 0.28% of vanilla aroma (ARO10703, IFF, Buenos Aires, Argentina), and 2% of cacao (Zanetti, Montevideo, Uruguay) were used as flavouring in whole and skimmed milk containing 8% sucrose.

Evaluations for investigating the effects of sucrose, polydextrose and flavourings were performed in duplicate. A total of two sessions on separate days were carried out. Solutions (10 mL) were presented in plastic 60 mL containers at room temperature coded with 3-digit random numbers. Assessors evaluated bitterness, astringency, sweetness and characteristic flavor intensity using unstructured 10-cm-long scales anchored with 'nil' and 'high'. The samples were presented in balanced random order. The assessors were instructed to pour the whole sample in their mouth, hold it for 3 seconds and rate the bitterness, astringency, sweetness, milky flavor and native plant characteristic flavour. Assessors rinsed their mouths with water four times during a 2 minute interval between samples. The testing was carried out in a sensory laboratory that was designed in accordance with ISO 8589 (ISO, 1988). Evaluations were performed under red light, temperature control (between 22 and 24ºC) and air circulation.

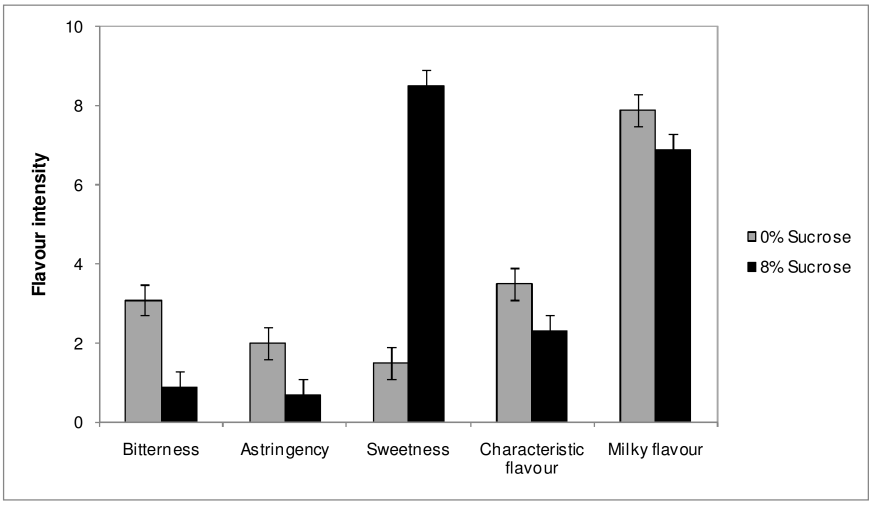
4.4.2. RESULTS AND DISCUSSION

4.4.2.1. Influence of sucrose on the sensory characteristics of an antioxidant extract in whole and skimmed milk

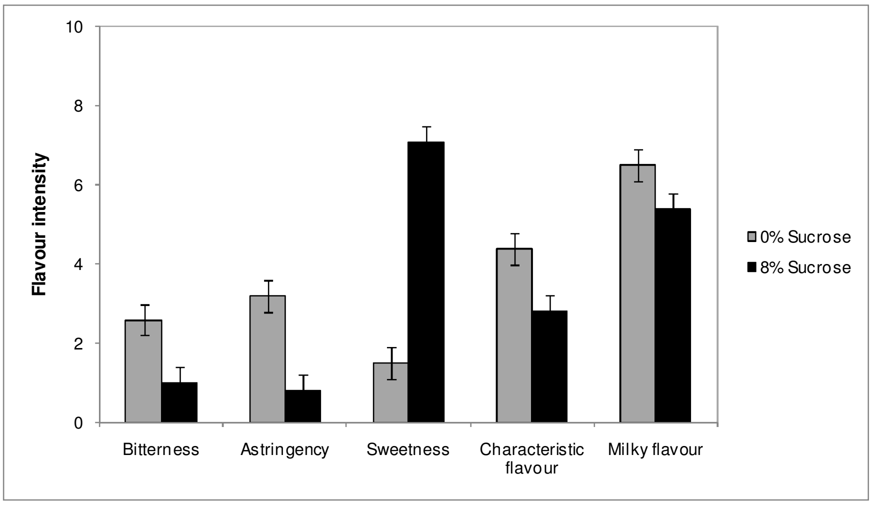
According to ANOVA, sucrose caused a highly significant ($p<0.001$) decrease in the bitterness, astringency and characteristic flavour of the antioxidant extracts. Moreover, sucrose caused a highly significant ($p<0.001$) increase in sweetness and a highly significant ($p<0.001$) decrease in milky flavour (c.f. Figure 4.7). Thus, sweetness was an effective alternative to further reduce the bitterness, astringency and characteristic flavour of the antioxidant extract in whole and skimmed milk. These results are in agreement with those discussed in Section 4.3.3.

Characteristic flavour showed the smallest decrease when 8% sucrose was added to whole or skimmed milk. As shown in Table 4.5 while the addition of sucrose caused a decrease in bitterness and astringency that ranged from 62.8% to 73.8%, it only caused a decrease of approximately 35% in the characteristic flavour of the extract.

(a)



(b)



Vertical lines represent Tukey's honestly significant differences ($p<0.05$).

Figure 4.6. Influence of 8% sucrose on bitterness, astringency, sweetness, characteristic flavour and milky flavour of antioxidant extracts from *Achyrocline satureioides* in: **(a)** whole and **(b)** skimmed milk.

Therefore, results suggest that characteristic flavour might limit the application of antioxidant extracts from *Achyrocline satureioides* as functional ingredient in sweetened dairy products. For this reason the use of other alternatives in addition to sucrose, such as flavourings, should be studied to achieve a greater reduction of characteristic flavour.

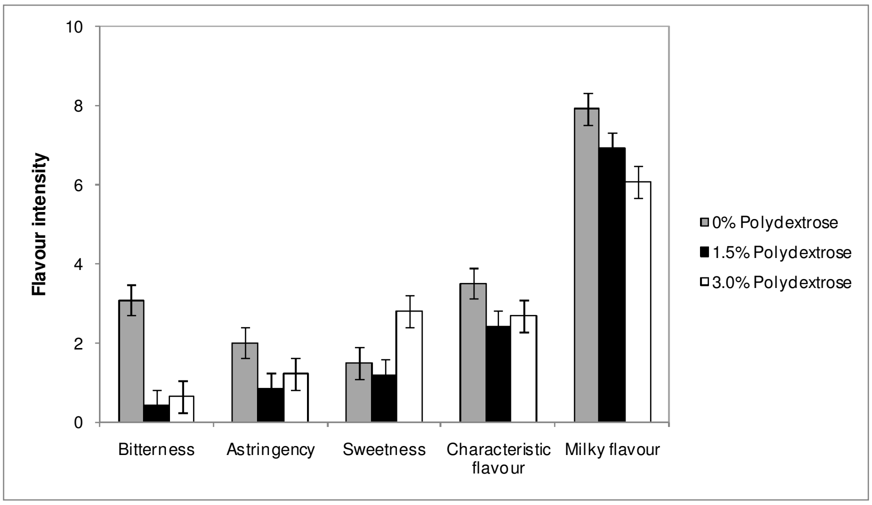
Table 4.5. Percentage of decreasing in bitterness, astringency and characteristic flavour of milk containing water extract from *Achyrocline satureioides* when 8% sucrose was added.

Type of milk	Percentage of decreasing in flavour intensity due to the addition of 8% of sucrose		
	Bitterness	Astringency	Characteristic flavour
Whole (3.2 % fat)	62.8	73.8	36.1
Skimmed (0% fat)	69.7	65.3	34.1

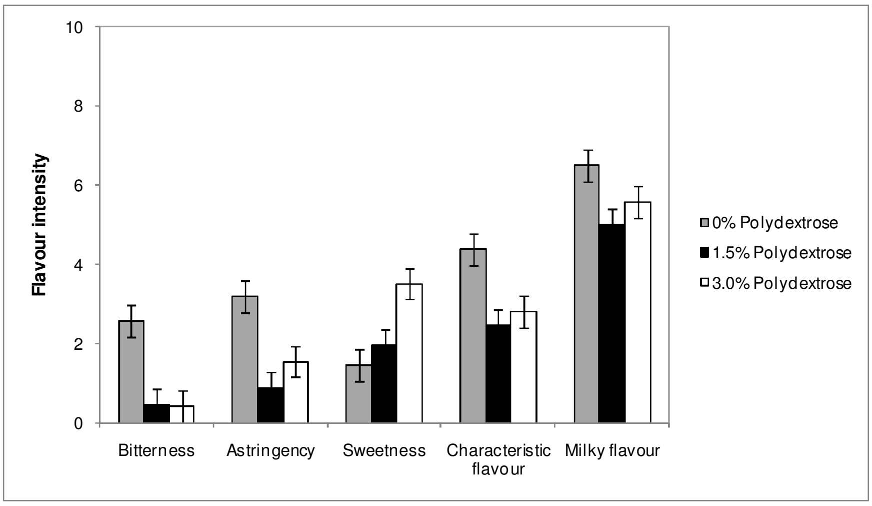
4.4.2.2. Influence of polydextrose on the sensory characteristics of an antioxidant extract in whole and skimmed milk

The addition of polydextrose led to a highly significant ($p<0.001$) decrease in the bitterness, astringency and characteristic flavour of the antioxidant extracts. Moreover, as shown in Figure 4.7, the addition of polydextrose caused a highly significant ($p<0.001$) increase in sweetness and a highly significant ($p<0.001$) decrease in milky flavour. These results confirm the efficacy of polydextrose in masking undesirable flavours such as bitterness, astringency and characteristic flavour of antioxidant extracts.

(a)



(b)



Vertical lines represent Tukey's honestly significant differences ($p<0.05$).

Figure 4.7. Influence of polydextrose on bitterness, astringency, sweetness, characteristic flavour and milky flavour of antioxidant extracts from *Achyrocline satureioides* in: **(a)** whole and **(b)** skimmed milk.

As discussed in Section 4.3.3 the addition of polydextrose only caused a slight increase in sweetness, which could be an advantage when a flavour needs to be masked without a modification of this sensory attribute.

As shown in Figure 4.7 the addition of 3.0% polydextrose caused the same decrease in bitterness, astringency and characteristic flavour than the addition of 1.5%. Furthermore, as shown in Table 4.6, the efficacy of polydextrose in masking bitterness, astringency and characteristic flavour was similar than that of sucrose. The smallest decrease was observed for characteristic flavour, stressing the importance of studying other ingredients that could achieve a decrease in its intensity.

Table 4.6. Percentage of decreasing in bitterness, astringency and characteristic flavour of milk containing water extract from *Achyrocline satureioides* when 1.5 and 3.0% polydextrose was added.

Type of milk	Polydextrose concentration (%)	Percentage of decreasing in flavour intensity due to the addition of 8% of sucrose		
		Bitterness	Astringency	Characteristic flavour
Whole (3.2 % fat)	1.5	86.5	57.4	30.7
	3.0	78.7	39.6	23.3
Skimmed (0% fat)	1.5	81.4	71.9	43.4
	3.0	83.7	51.3	36.1

4.4.2.3. Influence of polydextrose on the sensory characteristics of an antioxidant extract in sweetened whole and skimmed milk

According to ANOVA, the addition of polydextrose to sweetened whole and skimmed milk containing a water extract from *Achyrocline satureioides* did not significantly modify the investigated sensory attributes. As shown in Figure 4.8, bitterness, astringency, sweetness, characteristic flavour and milky flavour did not significantly ($p>0.05$) change. Therefore, the effect of sucrose and polydextrose did not sum up, as the addition of both ingredients achieved the same decrease in bitterness, astringency and characteristic flavour as that achieved with their individual addition.

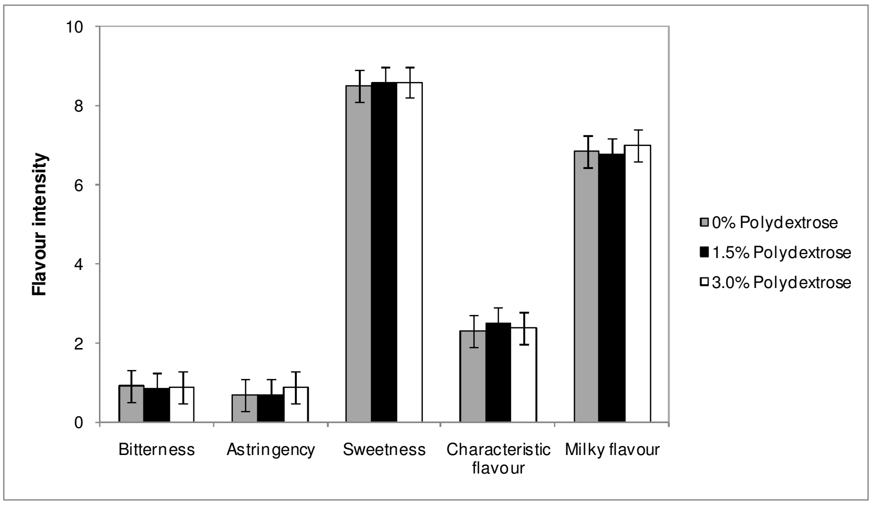
4.4.2.4. Influence of flavourings on the sensory characteristics of an antioxidant extract in sweetened whole and skimmed milk

According to ANOVA, the addition of flavourings highly significantly ($p<0.001$) affected the bitterness, sweetness, characteristic flavour and milky flavour of the water extract from *Achyrolicline satureioides* in sweetened whole and skimmed milk. On the other hand, the addition of flavourings did not significantly ($p>0.05$) affect the astringency of the extract in both the sweetened whole and skimmed milk.

As shown in Figure 4.9, the addition of 0.28% vanilla aroma caused a significant ($p<0.05$) decrease in the bitterness, sweetness and milky flavour of the extract in both whole and skimmed milk. However, this flavouring did not cause a significant change in the characteristic flavour of the extract, in both whole and skimmed milk.

These results suggest that the addition of extracts from *Achyrolicline satureioides* to vanilla milk products would not be recommended as they might show high characteristic flavour intensity.

(a)



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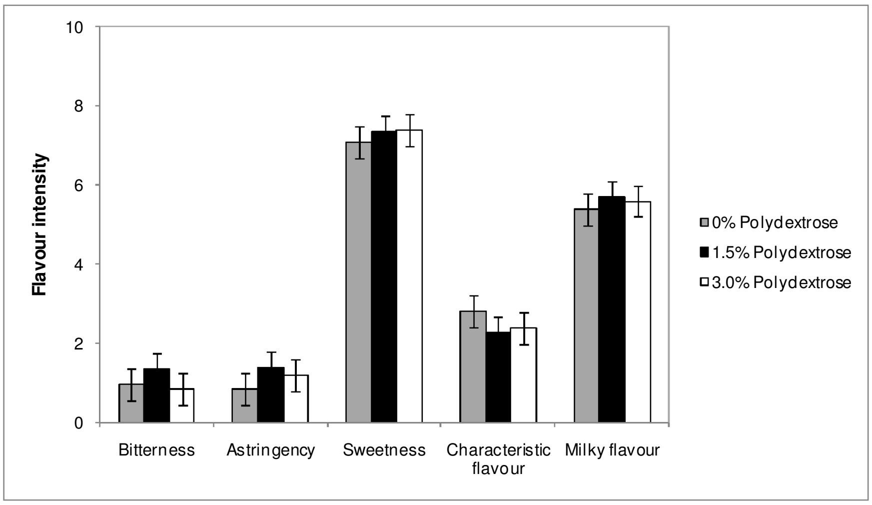
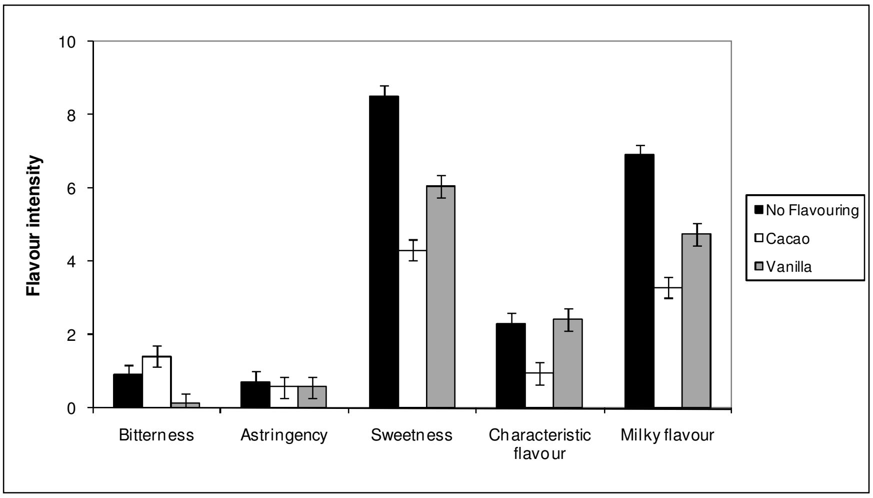


Vertical lines represent Tukey's honestly significant differences ($p<0.05$).

Figure 4.8. Influence of polydextrose on bitterness, astringency, sweetness, characteristic flavour and milky flavour of antioxidant extracts from *Achyrocline satureioides* in: **(a)** whole and **(b)** skimmed sweetened milk.

(a)



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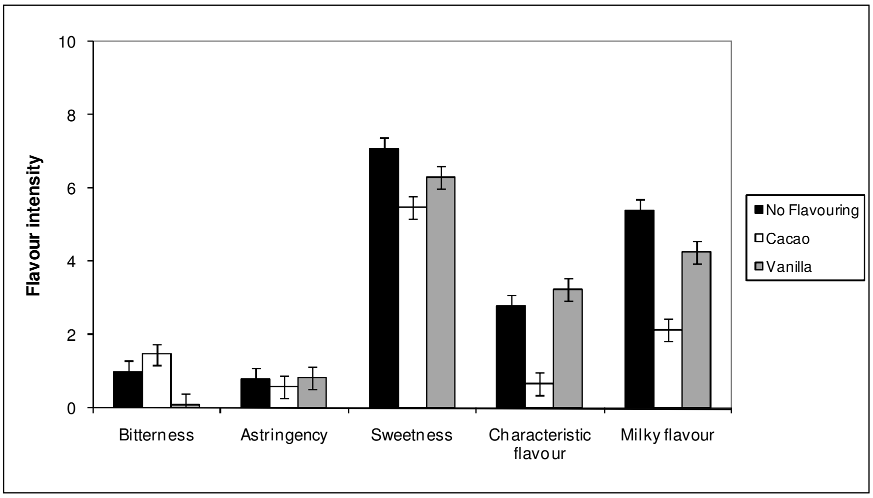


Vertical lines represent Tukey's honestly significant differences ($p<0.05$).

Figure 4.9. Influence of flavourings (2% cacao and 0.28% vanilla aroma) on bitterness, astringency, sweetness, characteristic flavour and milky flavour of antioxidant extracts from *Achyrocline satureioides* in: **(a)** whole and **(b)** skimmed sweetened milk.

On the other hand, the addition of 2% cacao resulted in a significant ($p<0.05$) decrease in the sweetness, characteristic flavour and milky flavour of the extract in both whole and skimmed milk (c.f. Figure 4.9). However, this flavouring did not cause a significant change in the bitterness of the extract, in both whole and skimmed milk. The addition of cacao caused a decrease in characteristic flavour of 57 and 75% when the extract was diluted in whole and skimmed milk, respectively. This flavour reached an intensity close to one on the scale, which indicates the efficiency of cacao in reducing such flavour.

4.4.4. PARTIAL CONCLUSIONS

The addition of sucrose and polydextrose were efficient in reducing the bitterness, astringency and characteristic flavour of whole and skimmed milk containing a water extract from *Achyrocline satureioides*. The smallest decrease was found in characteristic flavour, suggesting that this flavour might limit the application of the evaluated antioxidant extract in milk products.

On the other hand, the addition of vanilla aroma to sweetened whole and skimmed milk containing a water extract from *Achyrocline satureioides* did not significantly change characteristic flavour intensity. On the other hand, the addition of cacao led to a highly significant change in the intensity of this flavour.

These results suggest that flavourings with a very intense flavour are needed to mask the characteristic flavour of *Achyrocline satureioides* water extracts.

Sweetened whole and skimmed milk containing a water extract from *Achyrocline satureioides*, flavoured with 2% cacao, showed a low intensity of undesired flavours such as bitter, astringent and characteristic flavour. This suggests that sweetened dairy products flavoured with chocolate could be interesting base products for the development of functional foods containing antioxidant extracts from *Achyrocline satureioides.*

4.5. GENERAL CONCLUSIONS

Highly significant differences were found in the polyphenolic content and antioxidant capacity of the extracts from Uruguayan native plants, depending on the native plant and used solvent. Highly significant differences were also found in the sensory characteristics of the extracts. No significant correlation was found between the sensory characteristics of the extracts and their total polyphenolic content, suggesting that differences in the sensory characteristics might be explained by differences in the composition of polyphenolic compounds or by the concentration of other non-polyphenolic compounds. Further research is necessary to deepen the understanding of the relationship between the sensory profile of antioxidant extracts and their composition.

Moreover, all the evaluated solvent extracts of Uruguayan native plants showed a high intensity of bitterness, astringency and characteristic flavour, which could limit their application as functional ingredients in food products. These results suggested that the optimization of extraction conditions should be carried out considering both the antioxidant capacity and the sensory characteristics of the extracts. Other extraction conditions, such as solvent mixtures or other extraction times and temperatures, should be studied in order to achieve a better balance between the antioxidant capacity and the sensory characteristics of the extracts.

Water extracts from *Baccharis trimera* and *Achyrocline saturoides* showed the highest polyphenolic content and antioxidant capacity and the lowest bitterness, astringency and characteristic flavour intensity. Thus, these two extracts were selected as potential functional ingredients.

Considering the sensory attributes of the extracts, it is necessary to study the influence of different ingredients to mask their undesirable flavours (i.e. bitterness, astringency and characteristic flavour). Sucrose and milk proved to be interesting alternatives to reduce such attributes. Therefore, sweetened dairy products appear as potential base products for the development of functional foods enriched with this type of antioxidant compounds. Considering that the interaction between polyphenols and milk proteins might be responsible for the inhibition of undesired flavours, further research is necessary to study the bioavailability of polyphenolic compounds in dairy products.

Considering that cacao achieved the greatest inhibition of characteristic flavour, chocolate milk desserts could be considered as carriers for the development of a functional food enriched with an antioxidant extract from *Achyrocline saturoides*. Therefore, chocolate milk desserts enriched with antioxidants were the functional foods selected to be developed in the upcoming chapters.

CHAPTER 5

DEVELOPMENT OF REGULAR CHOCOLATE MILK DESSERTS

ABSTRACT

The aims of the present chapter were to identify drivers of liking of chocolate milk desserts, to select a formulation of chocolate milk dessert with high consumer acceptance, and to evaluate the use of projective mapping and a check-all-that-apply question to obtain a sensory profile of different formulations of chocolate milk desserts.

Two studies were carried out. In the first one, eight formulations of chocolate milk desserts were evaluated by two groups of consumers. Fifty consumers indicated their overall liking and answered a check-all-that-apply question. Meanwhile, forty consumers elicited up to four words to describe the desserts and completed a projective mapping task with a description phase.

In the second study, nine chocolate milk desserts with different sugar and cacao concentration were formulated. Seventy people were asked to score their overall liking and to answer a check-all-that-apply question that included both sensory and hedonic terms. Besides, the samples were evaluated by a trained sensory panel. Projective mapping and the check-all-that-apply question consisted on valuable tools to understand consumers' perception of the sensory characteristics of the products. Besides, these methodologies enabled the direct identification of drivers of liking of chocolate milk desserts. External preference mapping performed on the sensory maps obtained with these methodologies enabled the identification and development of samples with maximum consumers' overall liking. Using this approach, a formulation for a regular chocolate milk dessert that could serve as base product for the development of a functional product was selected.

5.1. INTRODUCTION

Considering the high competitiveness of today's markets, new food products that are launched to the market place should be aligned as much as possible with consumers' preferences (van Trijp *et al.*, 2007). Food companies should make efforts to optimize their food products according to different criteria in order to meet consumers' needs (Mao & Danzart, 2008).

During food product development, apart from knowing how much consumers like a product, information about which sensory characteristics consumers expect to find in the product is also needed. Thus, the sensory attributes that drive consumer liking, or drivers of liking, should be identified (Guinard *et al.*, 2001; ten Kleij & Musters, 2003). As consumers are not always able to say why they like a product (Elmore *et al.*, 1999), preference mapping techniques have been widely used to answer this question (Greenhoff & MacFie, 1994; Schlich, 1995; Murray & Delahunty, 2000; Guinard *et al.*, 2001; van Kleef *et al.*, 2006).

Preference mapping correlates consumer preference ratings to perceived sensory characteristics of the product in order to determine how the sensory characteristics of the product affect consumer liking scores (Arditti, 1997; van Kleef *et al.*, 2006). In external preference mapping liking scores are regressed onto the main factors of variability of the product sensory characteristics (Tenenhaus *et al.*, 2005). In the internal preference mapping the main factors of variability of liking scores are identified and linked to the sensory characteristics of the products (Tenenhaus *et al.*, 2005; van Kleef *et al.*, 2006).

Although preference mapping is one of the most popular tools of marketing and consumer research (Urban & Hauser, 1993; van Kleef *et al.*, 2006), it has several limitations (Krishnamurthy *et al.*, 2007; ten Kleij & Musters, 2003). In these techniques consumers are only asked how much they like the product, and therefore information about how they perceive the sensory characteristics of the product is not gathered. Thus, sensory information is obtained from a trained panel (Faye *et al.*, 2006). However, trained assessors could describe the product differently or take into account attributes that may be irrelevant for consumers (ten Kleij & Musters, 2003). Besides, since liking data is regressed onto principal components, it could be difficult to translate preference directions into product sensory attributes (Guinard *et al.*, 2001).

Sensory profiling is a powerful tool for the food industry as it provides important information for the development and marketing of new products, the reformulation of existing products and the optimization of manufacturing processes (Stone & Sidel, 1985; Meilgaard *et al.*, 1999). Traditionally, this methodology has been performed with a group of trained assessors who objectively provide a quantitative description of the sensory characteristics of food products (Stone & Sidel, 1985; Jelinek, 1985). Although quantitative descriptive analysis provides detailed, reliable and consistent results, it has some drawbacks. The application of quantitative descriptive analysis remains a very time-consuming approach since the vocabulary and associated training must be adapted to each product. Thus, there is industrial pressure to develop alternative methods that obviate the need to train a sensory panel, as well as to gather information from consumers (Faye *et al.*, 2006).

For decades, consumers have been considered only capable of hedonic judgments (Stone & Sidel, 1985; Meilgaard *et al.*, 1999). However, in order to design food products that meet consumer sensory expectations, food companies need information about how consumers perceive the sensory characteristics of the product (Guinard *et al.*, 2001; ten Kleij & Musters, 2003). Therefore, although descriptive data is useful to product development, the best way to understand consumer preferences is consumer data (Risvik *et al.*, 1997). In this context, several methods have been used to gather information about consumer perception of the sensory characteristics of a food product, such as intensity scales (Husson *et al.,* 2001), just-about-right (JAR) scales, repertory grid (Kelly, 1955), free choice profiling (Narain *et al.*, 2004), free sorting (Faye *et al.*, 2006), open-ended questions (ten Kleij & Musters, 2003; Ares *et al.*, 2009b) and attribute liking questions (Popper *et al.*, 2004).

However, there is concern that certain types of questions, such as intensity scales or just-about-right scales, could be a source of bias; for example by making certain product attributes especially salient in consumers' mind (Popper *et al.*, 2004). Another alternative is the use of check-all-that-apply questions (CATA). A CATA question consists of a list of words or phrases from which respondents should select all the words they consider appropriate to describe a product. This type of question has been used in consumer studies to determine which sensory attributes consumers perceive in a food product (Adams *et al.*, 2007;

Meullenet *et al.,* 2008a). Compared to just-about-right or intensity questions, CATA questions seem easier for consumers (Adams *et al.*, 2007).

Another alternative to traditional profiling is similarity scaling techniques. Risvik *et al.* (1994) introduced the idea of projective mapping to quantify individual perception of overall similarity and dissimilarity between products. This methodology could be carried out with consumers or trained assessors, who are asked to provide a two dimensional projection of a group of samples according to their own criteria (Risvik *et al.*, 1997). This technique could consist of a useful and simple way to evaluate consumer perception of food products. However, it has been mainly used with small group of semi-trained assessors or experts (Risvik *et al.*, 1994; Risvik *et al.*, 1997; Pagès, 2005; Perrin *et al.*, 2008). One of the disadvantages of this methodology is that the differences between samples are difficult to explain. Thus, the addition of a description phase to this task could provide additional information that could help understanding consumers' perception of samples (Pagès, 2005).

The aims of the present work were: **(a)** to identify drivers of liking of chocolate milk desserts; **(b)** to select a formulation of chocolate milk dessert with a high consumer acceptance; **(c)** evaluate the use of projective mapping with a description phase and a check-all-that-apply question to obtain a sensory profile of different formulations of chocolate milk desserts.

5.2. IDENTIFICATION OF DRIVERS OF LIKING OF MILK CHOCOLATE DESSERTS

5.2.1. MATERIALS AND METHODS

5.2.1.1. Samples

To study the influence of formulation on the sensory characteristics and consumers' overall liking of regular chocolate milk desserts, eight milk desserts with different formulation were used. These desserts were formulated following a $L_8 2^7$ Taguchi design (Gacula, 1993). Six two-level variables were considered in the study: starch, cacao, sugar, carragenan, polydextrose and vanilla concentrations. These variables were expected to have the greatest influence on the sensory profile of chocolate milk desserts, based on exploratory experiments, the formulation of milk desserts available in Uruguayan market, theoretical considerations, and published data (de Wijk *et al.*, 2003). The levels of each variable were selected considering preliminary studies and published data (de Wijk *et al.*, 2003; Ares *et al.*, 2009a; 2009b). Variables and levels are presented in Table 5.1.

Chocolate milk desserts were prepared in tap water using 12% powdered skimmed milk, commercial sugar, modified cooked up tapioca starch (National Frigex, National Starch, Trombudo Central, Brazil), cacao (Zanetti, Montevideo, Uruguay), polydextrose (Litesse® two, Danisco Sweeteners Ltd, Surrey, United Kingdom), vanilla aroma, carragenan (TIC PRETESTED Colloid 710 H Powder, TIC Gums, Belcamp, USA), and 0.1%

sodium tripolyphosphate. The rest of the formulation consisted of water up to 100%.

Table 5.1. Ingredient percentage composition of the eight samples of milk desserts formulated following a $L_8\,2^7$ Taguchi design.

Sample	Ingredient (%)					
	Starch	**Cacao**	**Sugar**	**Carragenan**	**Polydextrose**	**Vanilla**
1	2	2	12	0.04	0	0
2	2	2	14	0.05	3	0.05
3	2	3	14	0.05	0	0
4	2	3	12	0.04	3	0.05
5	3	2	14	0.04	0	0.05
6	3	2	12	0.05	3	0
7	3	3	12	0.05	0	0.05
8	3	3	14	0.04	3	0

Desserts were prepared by mixing the solid ingredients with water and poured into a Thermomix TM 31 (Vorwerk Mexico S. de R.L. de C.V., México D.F., México). The dispersion was heated at 90ºC for 5 min under strong agitation (1100 rpm). The desserts were placed in glass containers, closed, cooled to room temperature (25ºC) and then stored refrigerated (4-5ºC) for 24 h prior to the evaluation

5.2.1.2. Consumer panel

Ninety consumers, ages ranging between 18 and 60, were recruited from the city of Montevideo, Uruguay. Participants were 38% male and 62% female and were regular milk dessert consumers (at least once a week). Participants were randomly divided into two groups: one group of 40 people, who evaluated the desserts using a projective mapping task, and a second group of 50 consumers who evaluated the desserts using a 9-point hedonic scale, followed by a check-all-that-apply question.

For the projective mapping task, consumers were first asked to try each of the desserts and to provide up to four words they consider appropriate to describe them. After this, consumers were asked to place the samples on an A3 white sheet (60x40cm), according to the similarities or dissimilarities between them. Consumers were explained that they had to complete the task according to their own criteria and that there were no right or wrong answers. They were also explained that two samples close together on the sheet would correspond to very similar samples and that if they perceived two samples as very different they had to locate them very distant from each other. For each consumer map, the X and Y coordinates of each sample was determined, considering the left bottom corner of the sheet as origin of the coordinate system. The evaluation sheet used in this part of the study is shown in Appendix G.

For the check-all-that-apply study, the overall liking for each sample was scored by consumers using a 9-point hedonic scale followed by a check-all-that-apply (CATA) question with 17 hedonic and sensory attributes that they considered appropriate to describe the desserts. The words were selected based on results from a previous study in which consumers used an open-ended question to describe vanilla milk desserts (Ares *et al.*, 2009b).The attributes considered were the following: sweet, yummy, soft, thick, intense chocolate flavour, vanilla flavour, creamy, delicious, rough, not much sweet, disgusting, very thick, very sweet, not much thick, not much chocolate flavour, bitter, and not much creamy. The evaluation sheet used in the study is shown in Appendix H.

The eight milk desserts were presented to consumers following a balanced order (MacFie *et al.*, 1989). Thirty grams of desserts were served in 60-mL odorless plastic containers at 10ºC, codified with three-digit random numbers. Water was available for rinsing. The testing was carried out in a sensory laboratory that was designed in accordance with ISO 8589 (ISO, 1988). Evaluations were performed under artificial daylight type illumination, temperature control (between 22 and 24ºC) and air circulation, inside the sensory booths.

5.2.1.3. Data analysis

ANOVA was performed on consumer overall liking scores considering consumer, design variables, and sample as fixed sources of variation. Mean ratings were calculated and honestly significant differences were checked using Tukey's test ($p \leq 0.05$).

Internal preference mapping was carried out using a principal component analysis on the correlation matrix of consumer individual overall liking data.

Frequency of mention for each word of the check-all-that-apply question was determined by counting the number of consumers that used that word to describe each milk dessert. In order to evaluate if the check-all-that-apply question was able to detect differences in consumers' perception of the evaluated milk desserts, Friedman's test was carried out for each of the terms, considering sample and consumer as sources of variation.

A Multiple Factor Analysis (MFA) was performed on the frequency table containing responses to the CATA question. Consumer overall liking scores were considered as supplementary variable (Bécue-Bertaut *et al.* 2008; Bécue-Bertaut & Pagès 2008).

The elicited words provided by consumers in the projective mapping were qualitatively analyzed. First, a search for recurrent terms was performed. Terms with similar meaning were grouped into different categories within each milk dessert. This classification was performed independently by two researchers considering personal interpretation of the meaning of the words and word synonymy as determined by a Spanish dictionary. After individually evaluating the data, a meeting of the researchers was undertaken in order to check the agreement between their classifications. The final categories and their names were determined by consensus between the two researchers considering their three independent classifications and discussion between them. Categories mentioned by more than 10% of the consumers were considered. Frequencies in each category were determined by counting the number of consumers that used those words to describe each of the milk desserts. In order to evaluate if consumers described differently the evaluated milk desserts in the open-ended-question, chi-square was calculated on the frequency distribution of consumers' descriptions of the desserts.

Data from the projective mapping task consisted on the X and Y coordinates of the desserts in the sheet of each consumer. This data was analyzed using MFA, as suggested by Pagès (2005). Two types of analysis were considered. In the first one, the frequency table containing consumer descriptions was considered as a set of supplementary variables: correlation coefficients with the MFA factors were calculated but they did not participate in the construction of these factors (Pagès, 2005). Taking into account that consumers who performed the projective mapping task also provided the sample's descriptions, a second multiple factor analysis was performed considering both the table containing the coordinates and the frequency table of consumer descriptions. The advantage of this approach could be that the samples map is generated taking into account simultaneously both consumer evaluations.

In order to compare the sensory profiles generated by projective mapping and the CATA question, a hierarchical multiple factor analysis (HMFA) was carried out (Perrin *et al.*, 2008). This analysis was performed on a table composed of eight rows, corresponding to the eight desserts, and three groups of columns, corresponding to the words of the CATA question, the coordinates of the projective mapping task and consumer descriptions. HMFA first split the variables into two groups in order to compare the CATA question to the projective mapping task. The second level split the coordinates of the projective mapping task and the terms that consumer used to describe the samples. The advantage of this methodology is that it allows comparing samples' profiles in different methodologies; in this case projective mapping, consumers' descriptions and CATA counts (Le Dien & Pagès, 2003).

External preference mapping was used to link consumer overall liking scores and sensory data. This analysis was carried out as proposed by Danzart *et al.* (2004) using SensoMineR (Lê *et al.*, 2008b) in R language (R Development Core Team, 2007). A quadratic response surface was computed per consumer;

preference zones were delimited and finally superimposed. The percentage of consumers that liked a product with coordinates x and y on the sensory map were determined, i.e. the percentage of consumers who scored overall liking higher than 6. This analysis was carried out considering samples' coordinates in the consensus representation of the first two dimensions of the HMFA.

All statistical analyses were performed using Genstat Discovery Edition 2 (VSN International, Hemel Hempstead, UK) and R language (R Development Core Team, 2007). Multiple factor analysis and Hierarchical factor analysis were carried out using FactoMineR (Husson *et al.*, 2007; Lê *et al.*, 2008a).

5.2.2. RESULTS AND DISCUSSION

5.2.2.1. Overall liking scores

The mean overall liking scores of the evaluated samples ranged from 5.1 to 6.2, as shown in Table 5.2.

Table 5.2. Mean consumer overall liking scores of the eight evaluated chocolate milk desserts.

Sample	Mean overall liking scores §
1	5.1 ^{d}
2	5.3 ^{c,d}
3	6.1 ^{a,b}
4	5.5 ^{c,d}
5	6.2 ^{a}
6	5.7 ^{b,c}
7	6.0 ^{a,b}
8	6.0 ^{a,b}

Means with different superscripts are significantly different according to Tukey's test ($p<0.05$). §Evaluated in a 9-point hedonic scale.

Differences in the overall liking scores of the desserts were not large but were significant ($p<0.01$). Samples 3, 5, 7 and 8 showed the highest overall liking scores, whereas samples 1, 2 and 4 showed the lowest.

According to results from ANOVA, only starch and cacao had a significant effect ($p<0.05$) on consumer overall liking scores (c.f. Table 5.3). As shown in Table 5.4, increasing concentrations of these ingredients led to an increase in overall liking; except for sample 5 that had low cacao level and showed one of the highest acceptability scores. This suggests that interaction effects might be present between the evaluated variables. However, these interactions could not be evaluated due to the Taguchi experimental design considered. On the other hand, carragenan, vanilla, polydextrose and sugar had no significant effect on overall liking in the concentration range studied.

Table 5.3. F-ratios in the ANOVA of overall liking scores considering consumer and the six design factors as fixed sources of variation.

Factor	F-ratio
Consumer	2.57***
Starch	6.87**
Cacao	4.35*
Sugar	2.19 ^{ns}
Carragenan	0.15 ^{ns}
Polydextrose	1.05 ^{ns}
Vanilla	0.03 ^{ns}

*** indicates a highly significant effect ($p\leq0.001$), ** indicates a very significant effect ($p\leq0.01$), * indicates a significant effect ($p\leq0.05$), whereas ^{ns} indicates no significant effect ($p>0.05$).

Table 5.4. Mean consumers' overall liking scores for each of the six design factors (starch, cacao, sugar, carragenan, polydextrose and vanilla).

Factor and levels	Mean overall liking score §
Starch **	
2%	5.5 [a]
3%	6.0 [b]
Cacao*	
2%	5.6 [a]
3%	5.9 [b]
Sugar [ns]	
12%	5.6 [a]
14%	5.9 [a]
Carragenan [ns]	
0.04%	5.7 [a]
0.05%	5.8 [a]
Polydextrose [ns]	
0%	5.6 [a]
3%	5.8 [a]
Vanilla [ns]	
0%	5.7 [a]
0.05%	5.7 [a]

Factors indicated with *** had a highly significant effect on consumers' overall liking scores ($p<0.001$), whereas factors indicated with [ns] were not significant at a significance level of 0.05. Mean scores with different superscripts are significantly different. [§]Evaluated in a 9-point hedonic scale.

5.2.2.2. Internal preference mapping

Internal preference map revealed differences in preferences among consumers. Figure 5.1 shows consumers' representation in the first three dimensions of the PCA. The first three components of the PCA accounted for by 64.1% of the total variance, indicating the complexity of consumer preference and the heterogeneity in consumer behaviour.

Each point of Fig. 5.1 corresponds to the end point of a linear vector, representing increasing liking for a consumer. As shown, consumers were dispersed along the first three preference dimensions, which revealed the presence of subgroups of consumers with different preferences towards the evaluated chocolate milk desserts. This indicates that averaged overall liking scores might not provide a complete and accurate account of consumer preferences. The majority of consumers were located in the first, second and fourth quadrant, meanwhile there were also some consumers located in the third quadrant of the representation of the first and second preference dimensions; and in the first and fourth quadrant of the representation of the first and third preference dimensions.

The position of samples in the first three preference dimensions of the internal preference map is shown in Figure 5.2. Samples were distributed along the first two dimensions of the preference map. Samples 7 and 8 were located in the first quadrant, corresponding to the most liked samples for the group of consumers located to the right side of the first preference dimension. On the other hand, sample 6 was located in the fourth quadrant and samples 2 and 4 in the second quadrant of the representation of the first and second preference dimensions. The representation of the samples in the first and third preference dimensions was similar than the representation in the first two preference dimensions, except for the location of samples 3 and 5. These samples were grouped together in the first and second dimensions but were separated in the third preference dimension.

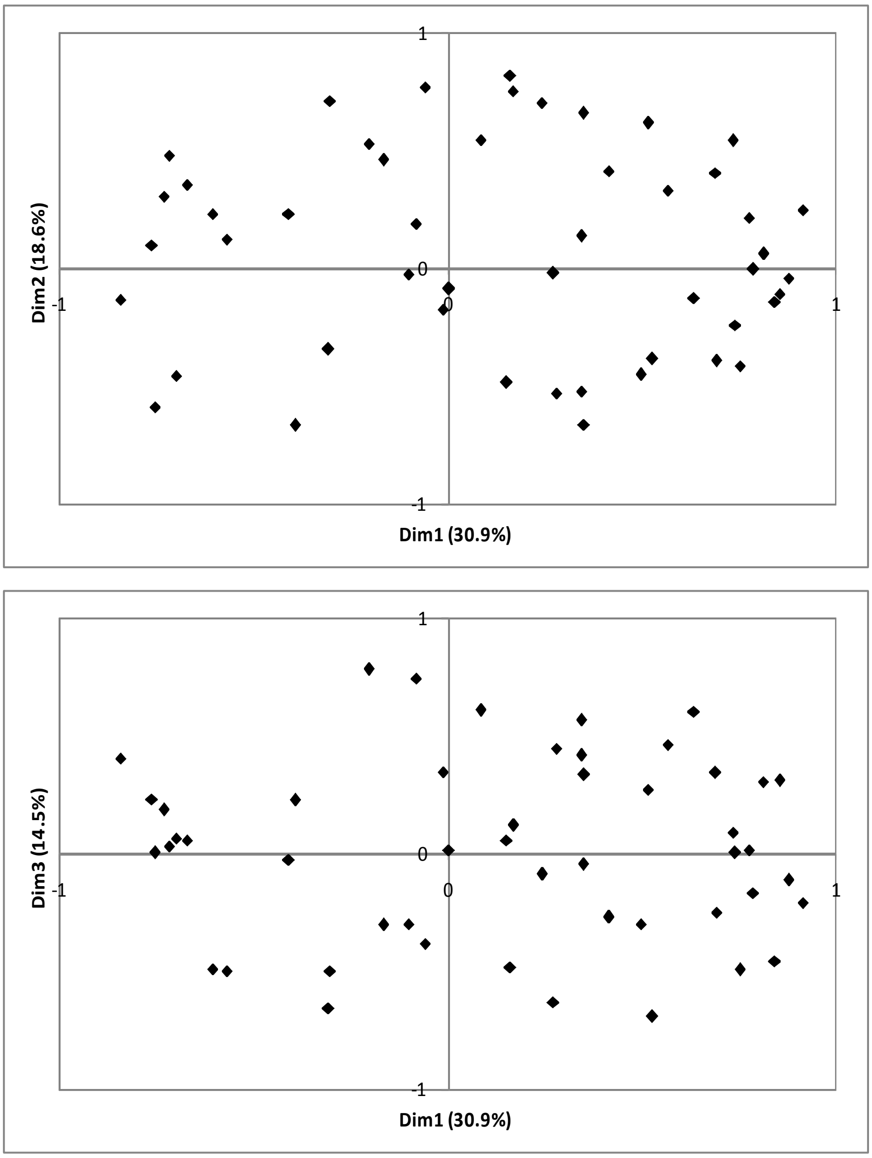


Figure 5.1. Internal preference mapping of consumers' overall liking data of the eight evaluated milk desserts. Representation of consumers in the first three preference dimensions.

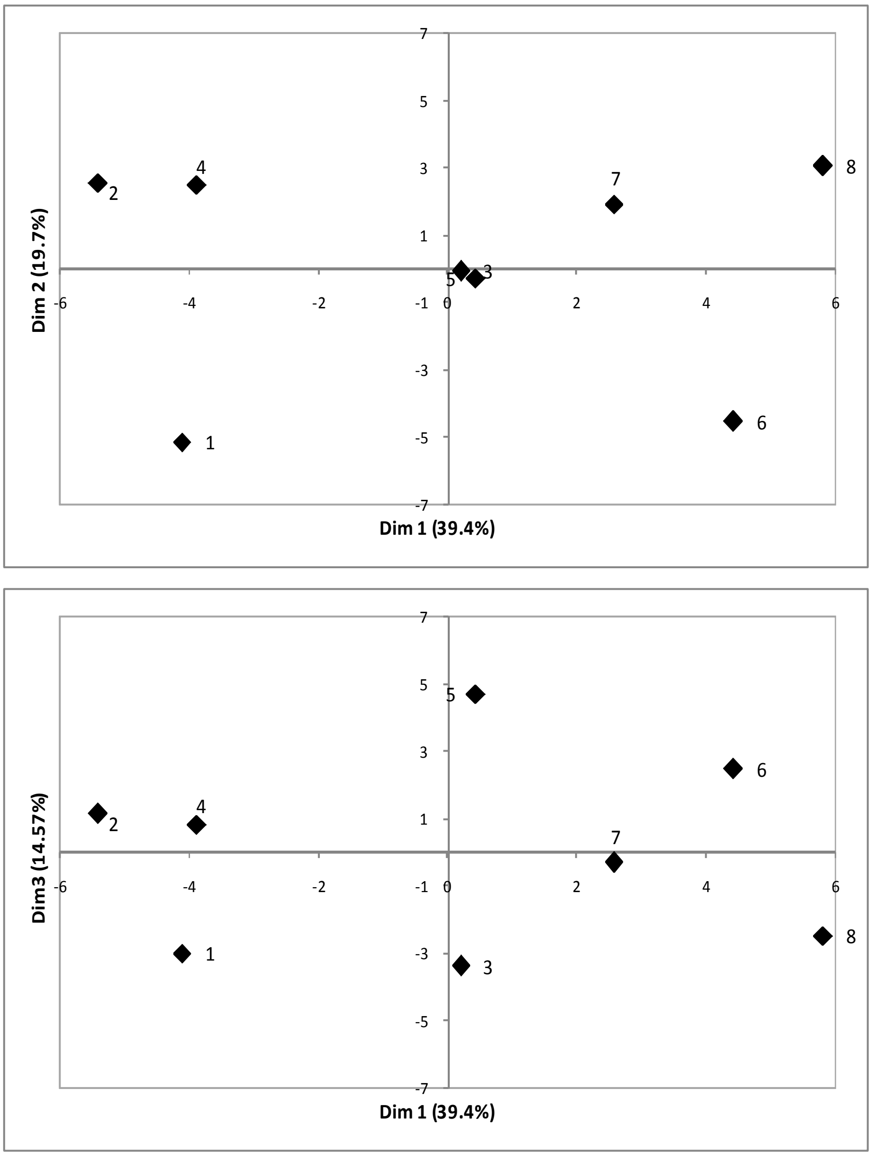


Figure 5.2. Internal preference mapping of consumers' overall liking data of the eight evaluated milk desserts. Position of samples in the first three preference dimensions.

It is interesting to notice that although samples 3 and 5 were among the samples which showed the highest mean overall liking scores, they were not located in the direction of increasing preference for any major group of consumers, revealing that they were not the most liked for the majority of consumers. Therefore, considering consumers' individual overall liking scores provided more accurate information for drawing conclusions regarding their preferences.

5.2.2.3. Check-all-that-apply question (CATA)

Consumers used between 1 and 8 terms to describe the desserts in the check-all-that-apply question. The most frequently used terms were 'sweet', 'soft', 'yummy', 'intense chocolate flavour' and 'thick'. Meanwhile, the least used term was 'delicious', followed by 'not much creamy' and 'rough'. The low frequency in which the term 'delicious' was mentioned could be explained by the fact that mean overall liking scores of the evaluated samples were equal or lower than 6.

Table 5.5 shows the percentage of consumers who used each of the terms of the CATA question to describe the eight evaluated chocolate milk desserts. Significant differences between the samples were found in the frequency in which 9 out of the 17 terms of the CATA question were used to describe the samples (c.f. Table 5.5). Significant differences were found for the terms related to the texture and flavour of the desserts. No significant differences were found for the terms 'yummy' and 'delicious', which could be due to the small differences found between the overall liking scores of the samples. On the other hand, significant differences were found in the frequency in which the term 'disgusting' was used for describing samples. These results suggest that this type of question was able to detect differences in consumers' perception of the chocolate milk desserts, particularly those related to their sensory characteristics.

Table 5.5. Percentage of consumers who used each term of the check-all-that-apply question to describe the chocolate milk dessert samples.

Term	Sample							
	1	2	3	4	5	6	7	8
Sweet ^{ns}	43	55	51	47	41	43	35	45
Yummy ^{ns}	33	22	33	24	31	29	45	37
Soft ***	41	39	51	47	47	39	29	16
Thick***	2	10	18	8	29	33	59	65
Intense chocolate flavour ***	24	24	37	29	18	18	41	51
Vanilla flavour	8	37	2	24	39	8	33	6
Creamy ^{ns}	12	24	27	35	24	27	18	18
Delicious ^{ns}	0	4	4	2	6	8	10	8
Rough ^{ns}	10	12	12	16	10	8	12	12
Not much sweet ^{ns}	27	14	20	12	16	27	22	18
Disgusting	22	16	4	20	8	20	6	10
Very thick ***	2	10	14	0	18	22	33	51
Very sweet **	6	22	8	18	27	10	8	4
Not much thick ***	29	33	24	16	4	8	8	0
Not much chocolate flavour ^{ns}	29	22	14	24	29	27	20	18
Bitter ***	12	4	22	29	6	10	24	29
Not much creamy ^{ns}	18	10	6	14	2	12	10	12

*** ($p \leq 0.001$), ** ($p \leq 0.01$), * $p \leq 0.05$), ^{ns} no significant differences ($p>0.05$); according to Friedman's test.

Multiple factor analysis was carried on out on CATA counts, considering overall liking scores as supplementary variables. The first three dimensions of the MFA accounted for 76.7% of the variance of the experimental data, representing 39.4%, 19.7% and 17.6% of the variance, respectively. As shown in Figure 5.3, the first dimension of the MFA contrasted positively with the terms ‘very thick’, ‘thick’, ‘bitter, ‘intense chocolate flavour’ ‘yummy’ and ‘delicious’; and negatively with the terms ‘soft’ and ‘not much thick’. This is in agreement with the fact that some of these terms were the most mentioned to describe samples, which explains their correlation with the dimension with the largest explained variance. On the other hand, the second dimension was negatively correlated to the terms ‘not creamy’ and ‘not much sweet’; and positively correlated to the term ‘rough’. The rest of the terms from the CATA question were correlated to the bisectors of the first and second quadrant. The bisector of the second quadrant of the representation of the first two dimensions of the MFA was positively correlated to the terms ‘sweet’, ‘very sweet’, ‘very creamy’ and ‘vanilla flavour’; whereas the bisector of the first quadrant contrasted negatively with the terms ‘not much chocolate flavour’ and ‘disgusting’. Moreover, the third dimension of the MFA was positively correlated to ‘rough’ and ‘not much creamy’; not providing much different information from the first two dimensions. The terms with the quantitative adjective ‘very’ were negatively correlated with the terms with the quantitative expression ‘not much’, suggesting that the use of these terms was related to attribute intensity. Therefore, despite the fact that the use of a CATA question does not directly provide a measure of the intensity of different sensory attributes, the use of quantitative adjectives could provide information about their intensity.

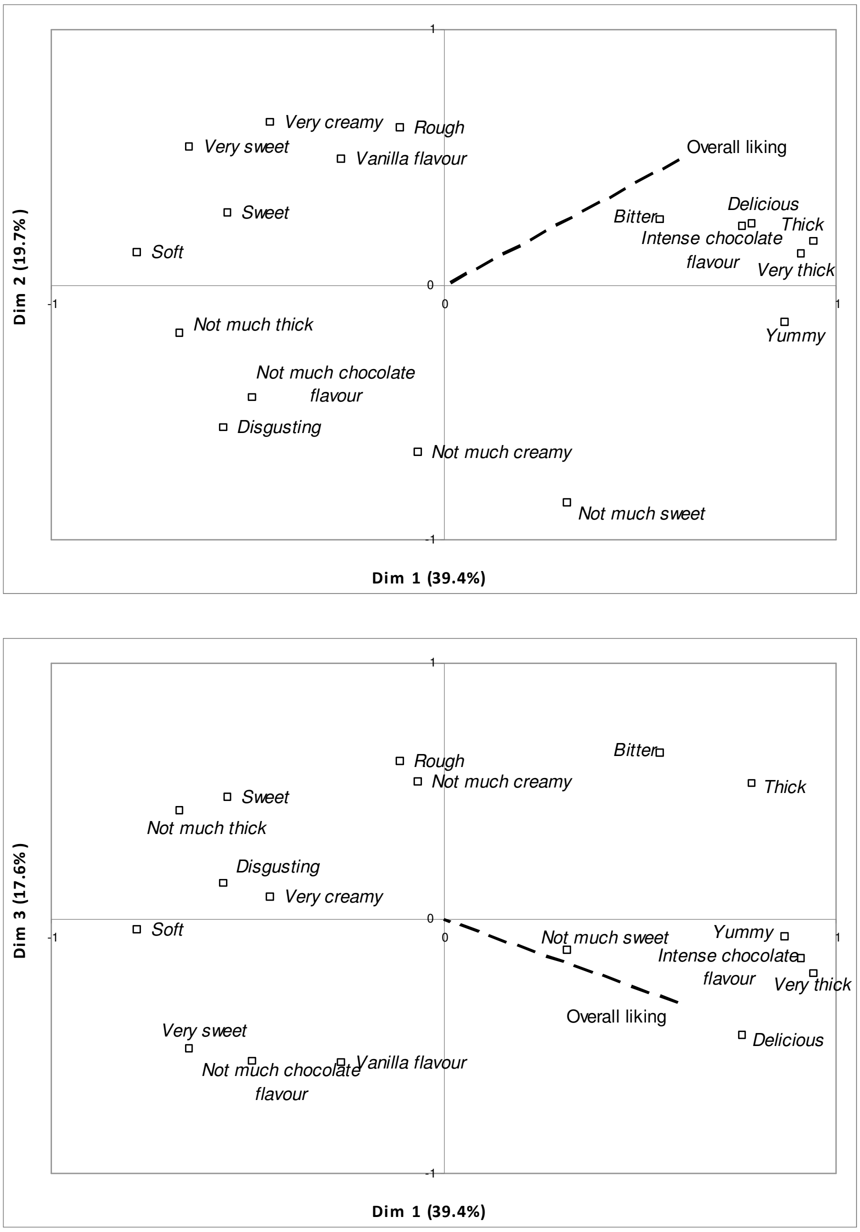


Figure 5.3. Representation of sensory and hedonic terms on the first three dimensions of the multiple factor analysis of CATA counts considering overall liking scores as supplementary variables.

Overall liking scores were positively correlated to the hedonic terms 'yummy' and 'delicious', and negatively correlated to 'disgusting', indicating the agreement between both evaluations.

As shown in Figure 5.3, the terms 'yummy' and 'delicious', as well as overall liking scores, were positively correlated to the terms 'thick', 'intense chocolate flavour' and 'bitter', suggesting that these sensory attributes were drivers of liking. On the contrary, the term 'disgusting' was correlated to the terms 'not much chocolate flavour' and 'not much thick', indicating that consumers might dislike samples with these sensory characteristics.

Figure 5.4 shows the representation of the desserts in the first three MFA dimensions. The first and second dimensions sorted the samples into four main groups, according to consumers' sensory and hedonic impressions. Samples 7 and 8 were located to the right side of the first dimension, corresponding to samples described as thick, bitter and with an intense chocolate flavour. These characteristics can be explained considering that these samples were formulated with the highest starch and cacao levels. These samples were also described as yummy and delicious, in agreement with the fact that they showed, together with samples 3 and 5, the highest mean overall liking scores. Samples 7 and 8 were separated into the third dimension. Sample 8 was located upper in the third dimension, since it was described as being less creamy and thicker than sample 7, in agreement with its higher sugar content.

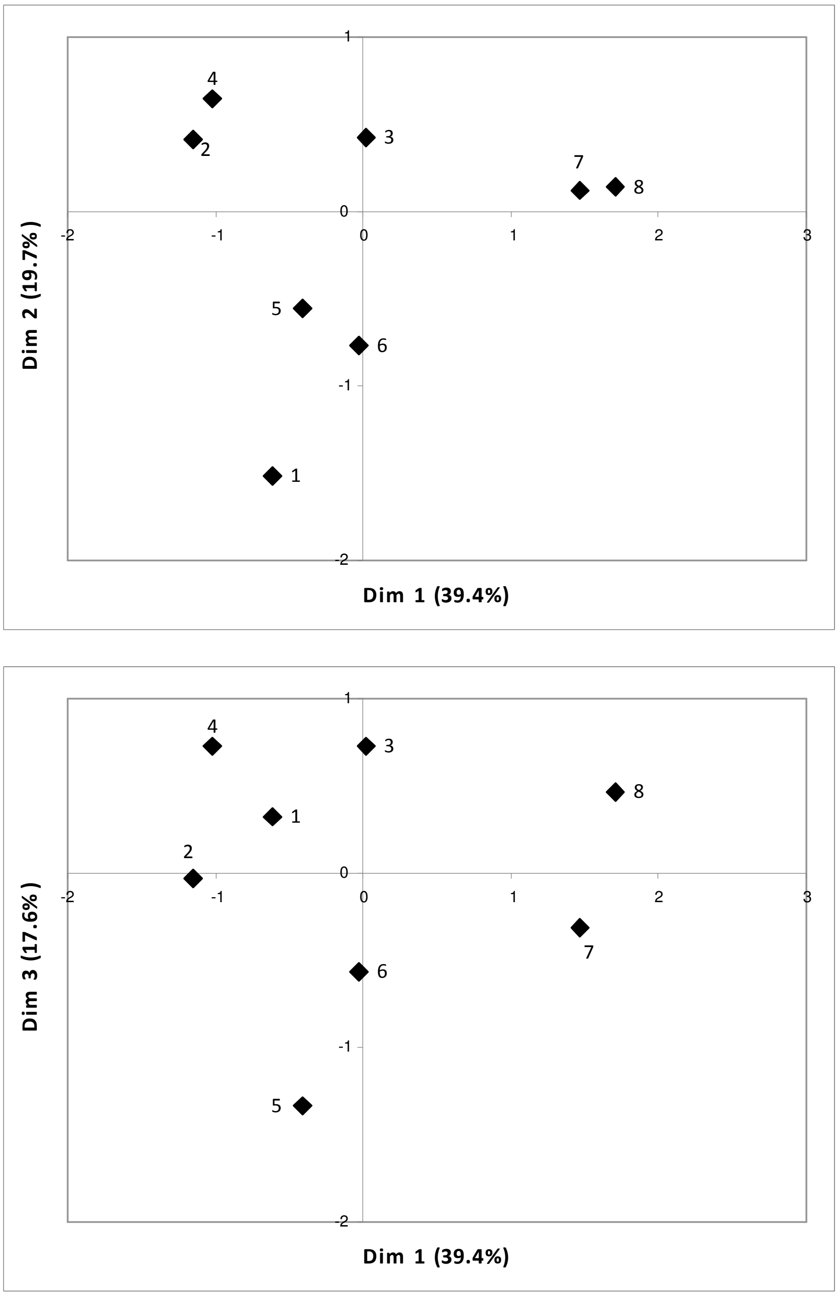


Figure 5.4. Representation of the eight chocolate milk desserts on the first three dimensions of the multiple factor analysis of CATA counts considering overall liking scores as supplementary variables.

Moreover, sample 1 was located down in the first dimension, and was mainly described as ‘not much thick’, ‘disgusting’ and ‘not much chocolate flavour’. These attributes were expected since this sample was formulated with the lowest level of all ingredients. Samples 5 and 6 showed intermediate characteristics between samples 7, 8, and sample 1, which could be explained by their highest starch level and the lowest cacao concentration. Furthermore, samples 2, 4 and 3 were located together in the second quadrant, and were described as sweet, creamy and soft. These samples were formulated with intermediate levels of the studied ingredients.

The second and third dimensions showed a similar pattern and sorted the samples into three groups.

5.2.2.4. Projective mapping

Respondents provided between one and five terms to describe each of the evaluated milk desserts. Table 5.6 shows the terms used by consumers to describe samples. Eighteen terms were mentioned by more than 10% of the consumers. These terms were related to hedonic and sensory characteristics, particularly appearance, texture and flavour attributes. The elicited terms were very similar to those used in the CATA question, which could be explained considering that the latter terms were selected taking into account consumers’ responses to an open-ended question (Ares *et al.*, 2009a). The most frequently used terms were ‘thick’, ‘not much thick’ and ‘chocolate flavour’. These terms were among the terms most checked in the CATA question, suggesting the concordance between both evaluations.

Table 5.6. Terms used by consumers for describing the desserts before the projective mapping task and number of mentions.

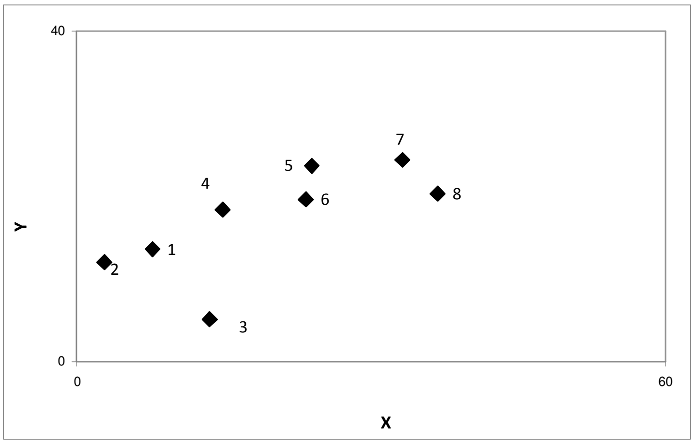
Category	Number of mentions
Thick	131
Not much thick	126
Intense chocolate flavour	117
Creamy	96
Sweet	90
Yummy	78
Rough	78
Bitter	59
Not much chocolate flavour	58
Very sweet	46
Soft	45
Light	40
Not much sweet	32
Vanilla flavour	29
Glossy	29
Disgusting	27
Dark	18
Very thick	14

Highly significant differences were found between the milk desserts consumers' descriptions (χ^2 = 361.5, $p<0.0001$). This indicates that participants used different terms to describe the sensory and hedonic characteristics of the desserts, suggesting that the open-ended-question was able to detect differences in consumers' perception of the evaluated products. The frequency in which each of the terms was used for describing the evaluated milk desserts is shown in Table 5.7.

Table 5.7. Percentage of consumers who used each of the terms for describing the eight evaluated milk desserts before the projective mapping task.

Category	Sample							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Thick	0	0	17	17	47	47	70	77
Not much thick	93	53	40	53	17	7	0	0
Intense chocolate flavour	7	17	30	40	23	17	47	63
Creamy	17	13	13	13	37	37	40	30
Sweet	23	30	37	17	23	7	37	13
Yummy	13	17	17	17	37	17	17	30
Rough	17	17	30	17	17	37	17	13
Bitter	13	7	13	23	7	13	30	17
Not much chocolate flavour	23	13	13	0	17	47	0	7
Very sweet	17	10	13	17	7	13	7	13
Soft	17	7	13	13	13	23	0	7
Light	23	17	7	7	17	13	0	0
Not much sweet	13	13	13	13	7	0	0	7
Vanilla flavour	0	17	0	17	13	0	13	0
Glossy	7	13	13	7	0	13	7	0
Disgusting	0	23	13	0	17	0	0	0
Dark	0	0	0	0	0	7	17	13
Very thick	0	0	0	0	0	0	13	17

All consumers were able to complete the projective mapping task. Consumers used most of the A3 sheet to draw their maps, mostly using both dimensions. Figure 5.5 shows two examples of consumers' maps. The majority of the maps had a similar appearance. There were two consumers who only used a vertical line and three who only used a horizontal line to locate the samples.



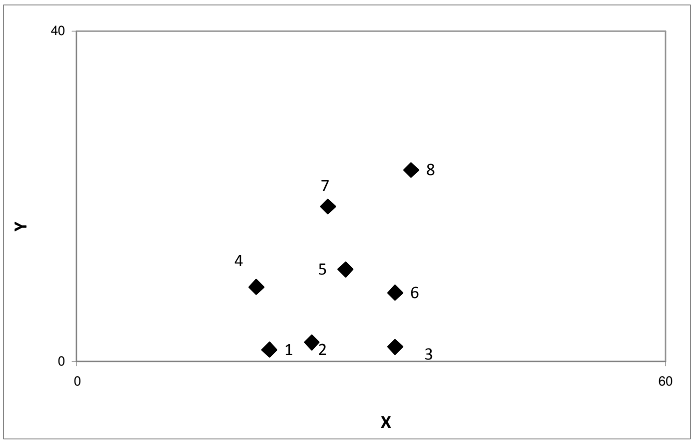


Figure 5.5. Example of two individual representations of the eight milk desserts in the A3 white sheet (60x40 cm).

The majority of consumers tended to use more the X coordinate than the Y coordinate to differentiate samples. Consumers used an average of 57.8% of the horizontal dimension of the sheet and 39.3% of the vertical dimension. This has been already reported by Pagès *et al.* (2005) and suggests that consumers tend to locate the samples along the horizontal dimension, maybe because it is the larger dimension of the sheet. Most studies about projective mapping have used sheets that are larger in the horizontal dimension than in the vertical one. It could be interesting to study if consumers behave differently if the sheet is oriented the other way, i.e. using a 40x60cm sheet.

Since each consumer used his/her own criteria to locate the samples, as expected, no conclusions can be drawn from the individual maps. Multiple factor analysis was carried out to get a configuration of samples. This methodology provided a consensus representation of the evaluated desserts.

Two types of multiple factor analysis were carried out on consumers' X and Y coordinates. In the first analysis, the samples' coordinates were considered as active variables and consumers' descriptions were considered as supplementary variables. In this analysis the samples were located only considering the projective mapping task and correlations between the MFA dimensions and consumers' descriptions were calculated to understand which attributes were responsible for the differences between samples. Figure 5.6 shows the representation of the desserts in the first three dimensions of the MFA of the projective mapping data. Samples were sorted into four groups, one group composed of samples 7 and 8, another of samples 5 and 6, whereas sample 1 was located apart from the rest of the samples, and samples 2, 3 and 4 were located in the second quadrant. This representation of the desserts is almost identical to that obtained considering CATA counts (c.f. Figure 5.4), suggesting that both methodologies provided very similar results.

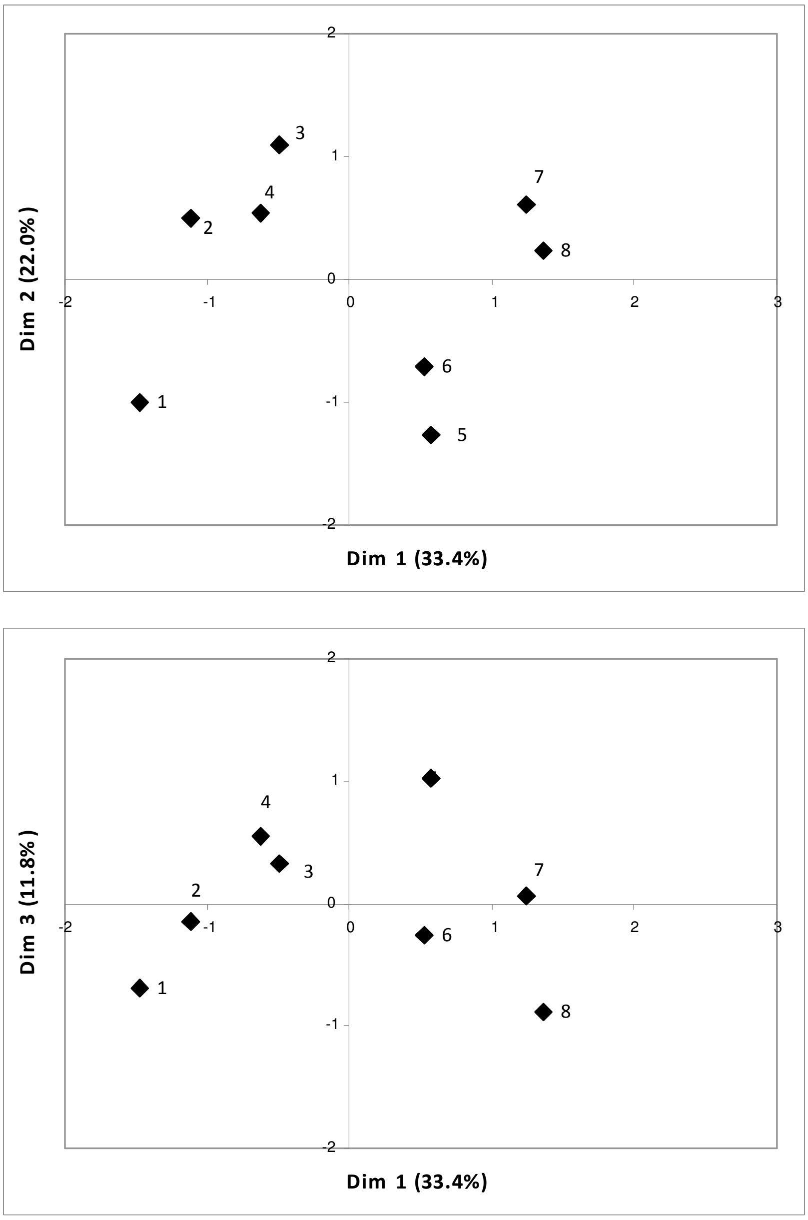


Figure 5.6. Representation of the eight chocolate milk desserts on the first three dimensions of the multiple factor analysis of projective mapping data considering consumers' descriptions as supplementary variables.

Consumers X and Y individual coordinates were widely spread inside the correlation circle (Figure 5.7), indicating that each consumer located the samples according to their own criterion. Most of the coordinates were correlated to the first dimension of the MFA, in agreement with the fact that it showed the highest explained variance.

Consumers' descriptions were considered as supplementary variables and correlations with the MFA dimensions were calculated. As shown in Figure 5.8, the first dimension of the MFA was positively correlated to the terms 'thick', 'dark', 'thick', 'very thick' and 'intense chocolate flavour', and negatively correlated to 'not much sweet', 'glossy', 'disgusting' and 'not much sweet'. These results are in agreement with those from CATA counts, which suggested that the main sensory attributes responsible for the differences between the evaluated samples were thickness, sweetness and chocolate flavour. Besides, the second dimension of the MFA was positively correlated to 'sweet' and negatively correlated to 'not much chocolate flavour'. The third dimension was related to 'vanilla flavour' and the hedonic term 'disgusting'. Considering the samples representation and the correlation of consumers' descriptions with the dimensions of the MFA, differences between samples could be described in terms of sensory and hedonic descriptions. Samples 7 and 8 corresponded to thick, dark samples with intense chocolate flavour, whereas sample 1 was described as light, soft, not much thick and with not much chocolate flavour.

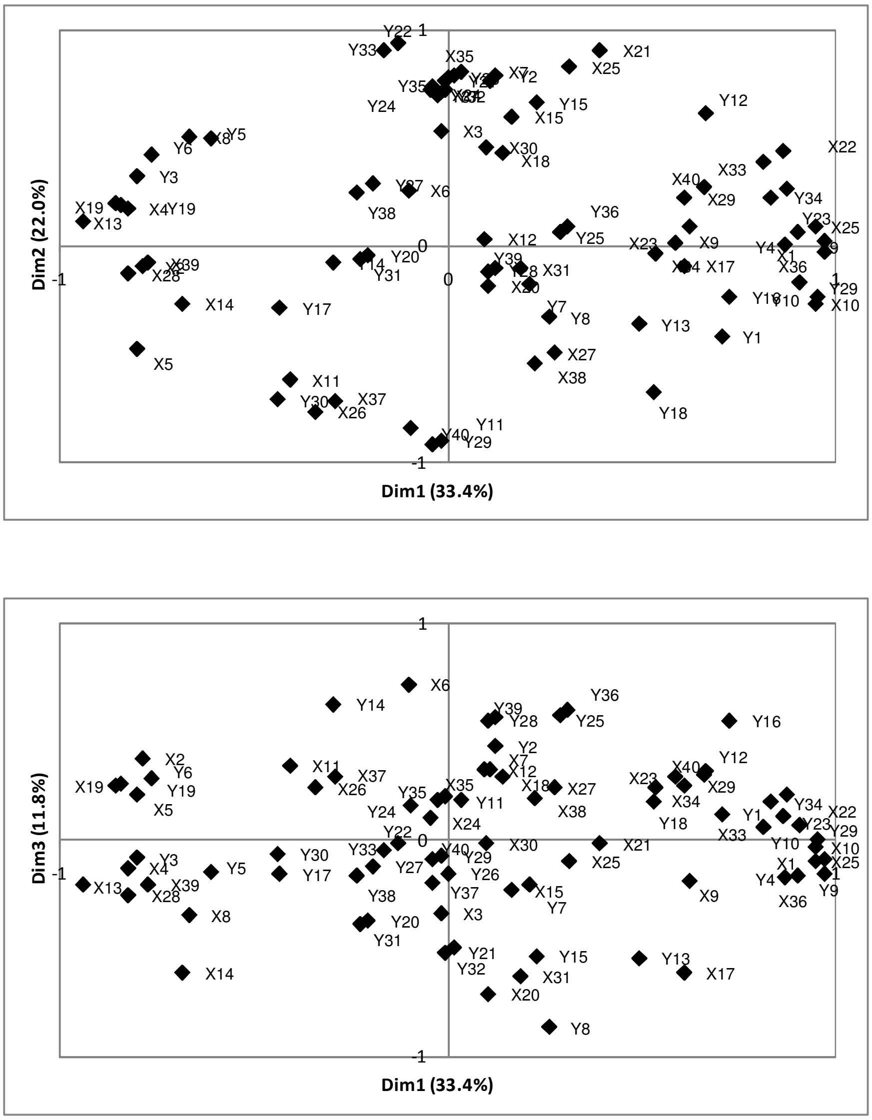


Figure 5.7. Representation of consumers' individual X and Y coordinates of the evaluated chocolate milk desserts, on the first three dimensions of the multiple factor analysis of projective mapping data considering consumers' descriptions as supplementary variables.

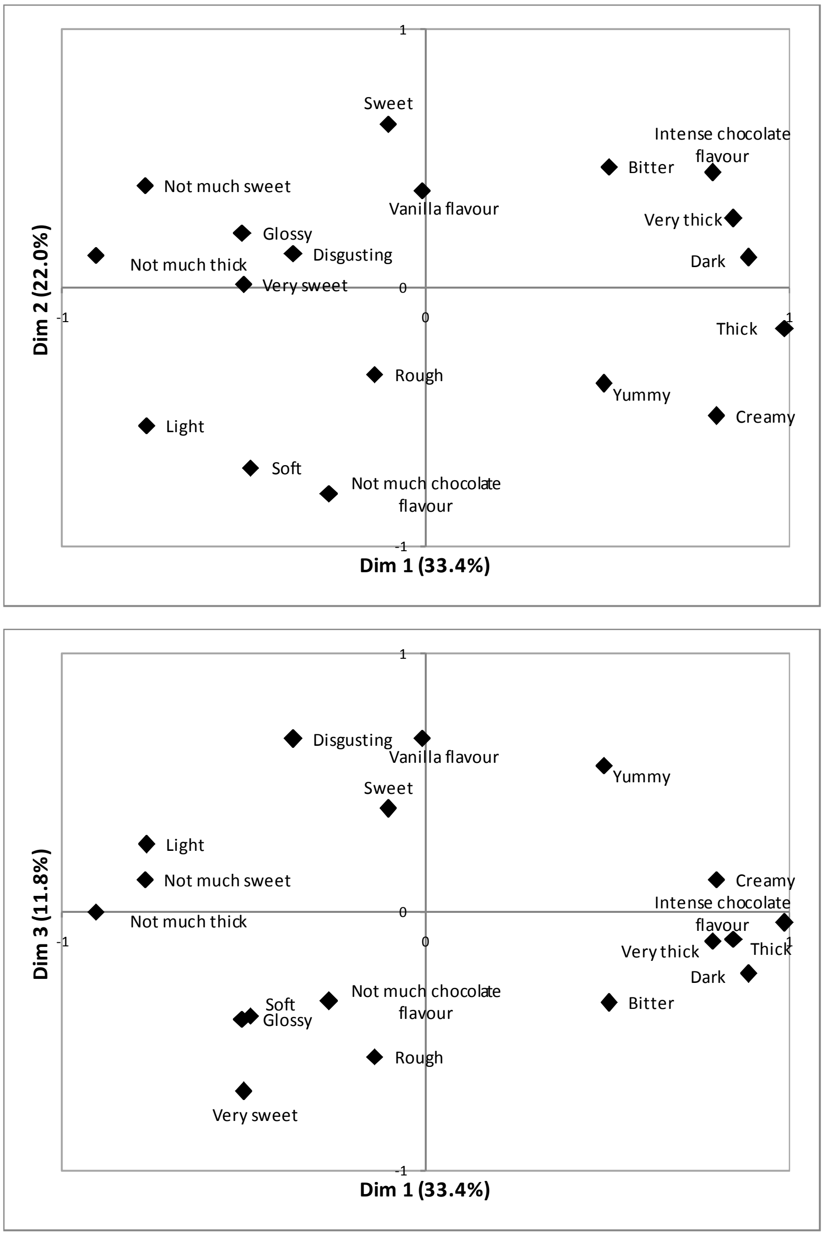


Figure 5.8. Projection of consumers' descriptions on the first three dimensions of the multiple factor analysis of projective mapping data considering consumers' descriptions as supplementary variables.

Moreover, samples 5 and 6 showed intermediate sensory characteristics between those of the previously mentioned groups of samples. These results are very similar to those from the MFA of CATA counts, suggesting the concordance of both methodologies.

Considering that the same consumers who completed the projective mapping task, provided terms which described samples, a MFA was carried out considering both sets of variables as active elements (Pagès, 2005). The advantage of this approach is that the samples are located considering both types of data. The first three dimensions of the MFA accounted for by 68.5% of the variance of the experimental data, representing 36.0%, 19.3% and 13.2% of the variance, respectively. Projective mapping data and consumers' descriptions contributed in a balanced way to the inertia of the first three dimensions (50.1% vs. 49.9%, 58.6% vs. 41.4% and 44.7% vs. 55.3% for the first, second and third dimension, respectively). This suggests that samples were located considering simultaneously both data sets. This might provide a more complete representation of the samples as it takes into account consumers' perception of similarities and differences between samples and also their descriptions. As shown in Figure 5.9, the representation of samples in the first three dimensions of this MFA is almost identical to that shown in Figure 5.6. Therefore, projective mapping data and consumers' descriptions provided the same information and equally discriminated the samples. Besides, the correlations of consumers' terms with the dimensions of the MFA are shown in Figure 5.10.

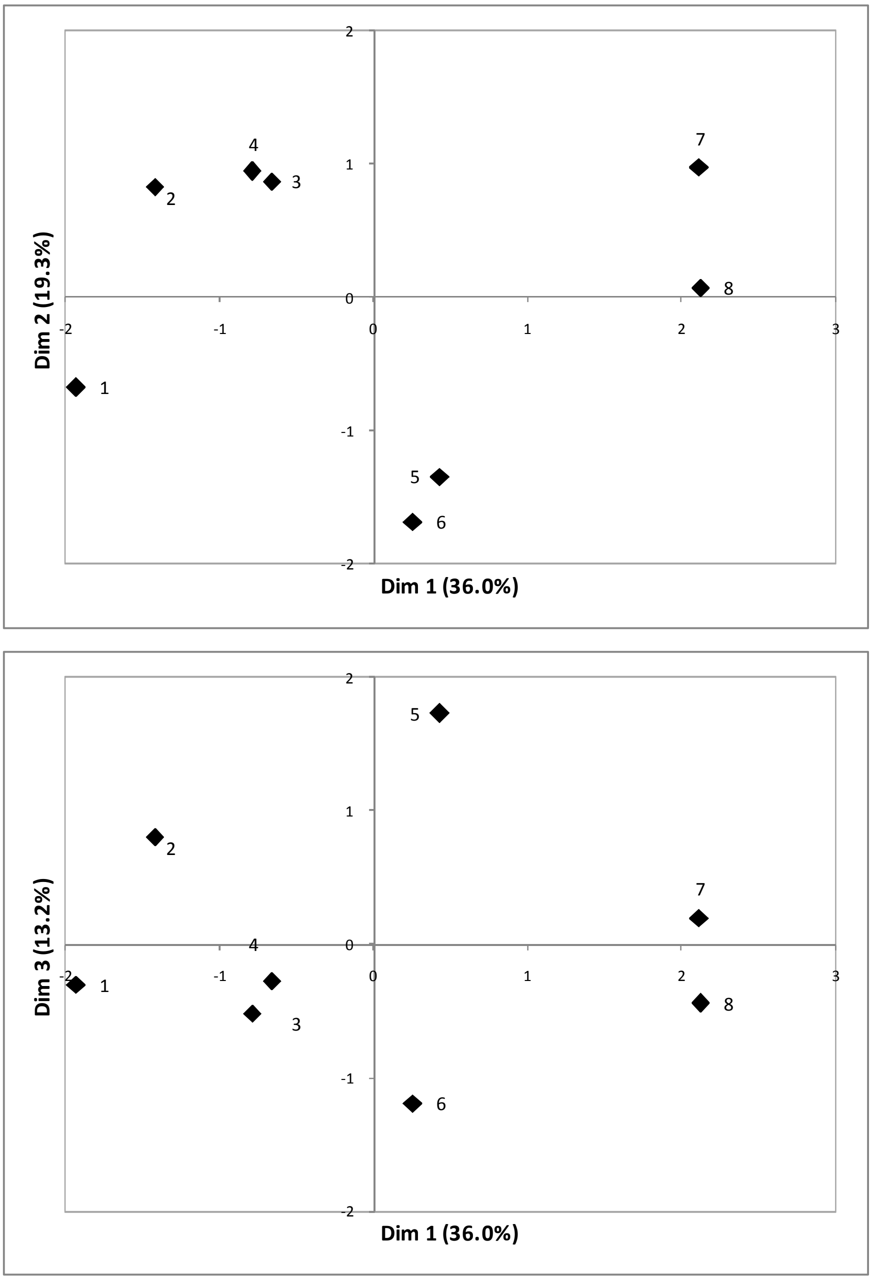


Figure 5.9. Representation of the eight chocolate milk desserts on the first three dimensions of the MFA of projective mapping data and consumers' descriptions as active data sets.

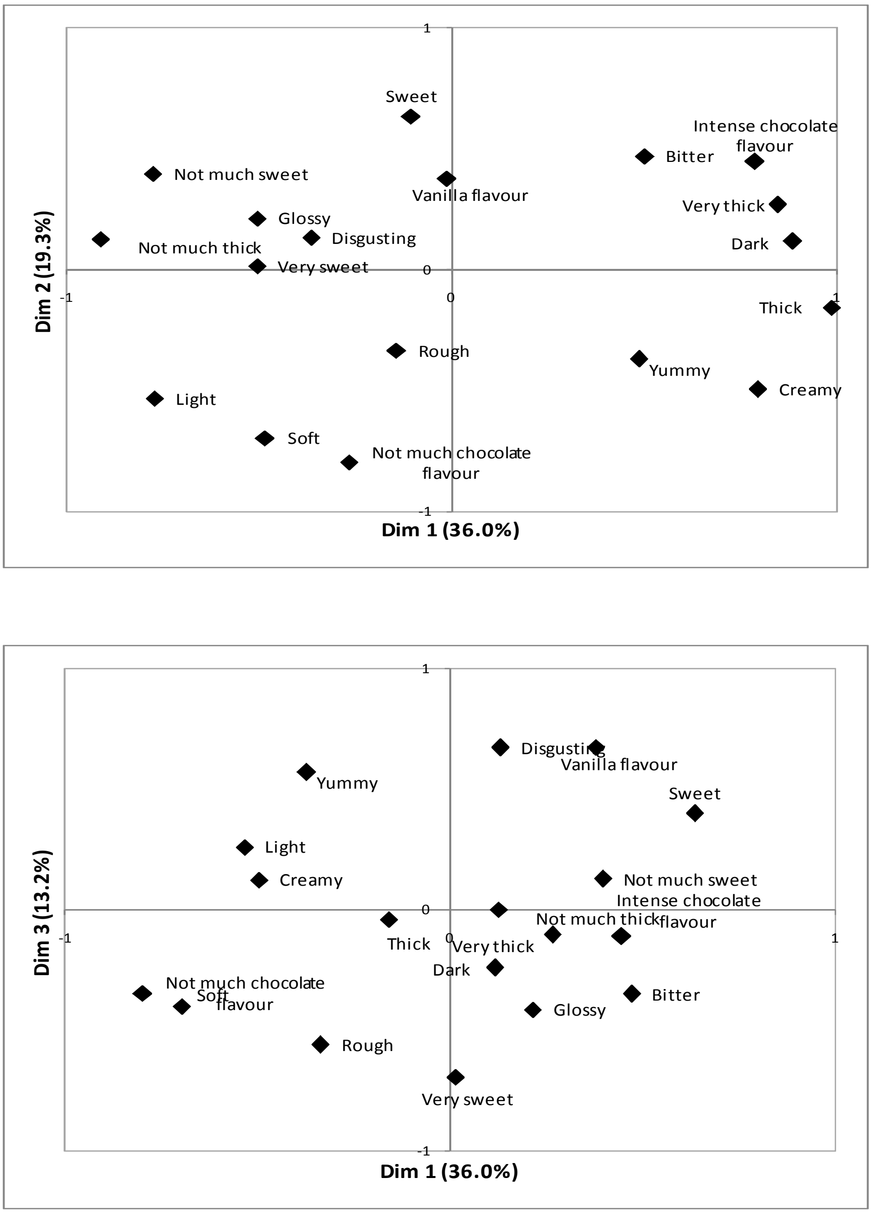


Figure 5.10. Representation of consumers' descriptions on the first three dimensions of the MFA of projective mapping data and consumers' descriptions as active data sets.

Correlations were also very similar to those shown in Figure 5.8, suggesting that both types of analysis provided similar information, and implying that the projective mapping task provided very similar information to the open-ended-question used to describe the chocolate milk desserts.

The combination of a projective mapping task with consumers' description provided more information and did not complicate the task. Using the combination of both techniques, samples were profiled according to their similarities and dissimilarities, but also considering consumers descriptions. Consumers' free descriptions complimented the projective mapping task as differences between the samples position in the map could be understood in terms of sensory and hedonic terms. It is also interesting to notice that samples were profiled in a very similar way using data from projective mapping task and consumers' descriptions.

5.2.2.5. Hierarchical multiple factor analysis (HMFA)

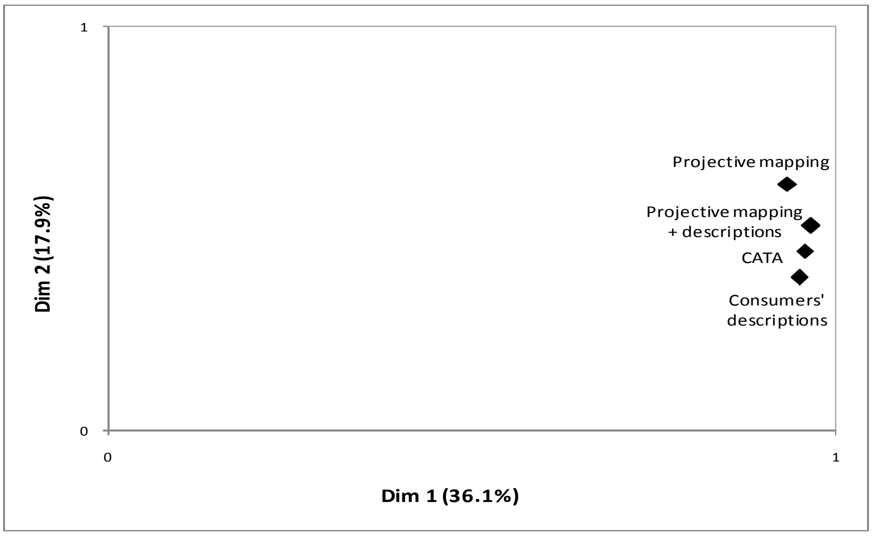
HMFA was used to compare results from CATA counts and projective mapping. In this analysis, data was first split into two groups to compare consumer profiling based on CATA counts and projective mapping with descriptions. Secondly, data was split within the projective mapping task to compare the samples' profile from the projective mapping task and from consumers' free descriptions.

Representation of the methods is shown in Figure 5.11. The proximity of the methods in the first three dimensions of the MFA indicates that they provided very similar information. Consumers' descriptions and responses to CATA questions were very close to each other, indicating their concordance. As discussed above, this could be related to the fact that similar terms were used in both methodologies.

Furthermore, the projective mapping task provided a representation very similar to that obtained through consumers' free descriptions or through their responses to the CATA question.

The superimposed representation of the methods allows evaluating the proximity between them for each sample. As shown in Figure 5.12, points corresponding to the two methods (CATA and projective mapping with descriptions) were close, suggesting that samples configurations were very similar for both methods. This shows that consumers used both methodologies similarly and therefore could be considered supplementary in the present study.

Although all consumers seemed to understand the projective mapping task some participants commented that they found it very difficult and further explanation was required to assure that consumers understood the task. It suggests that projective mapping could be difficult for people with low educational level. This task was more time-consuming than evaluating overall liking or answering a CATA question. On the other hand, the CATA question was a very simple task and very easy to understand. Therefore, although the three methodologies provided similar results they differed in their degree of difficulty.



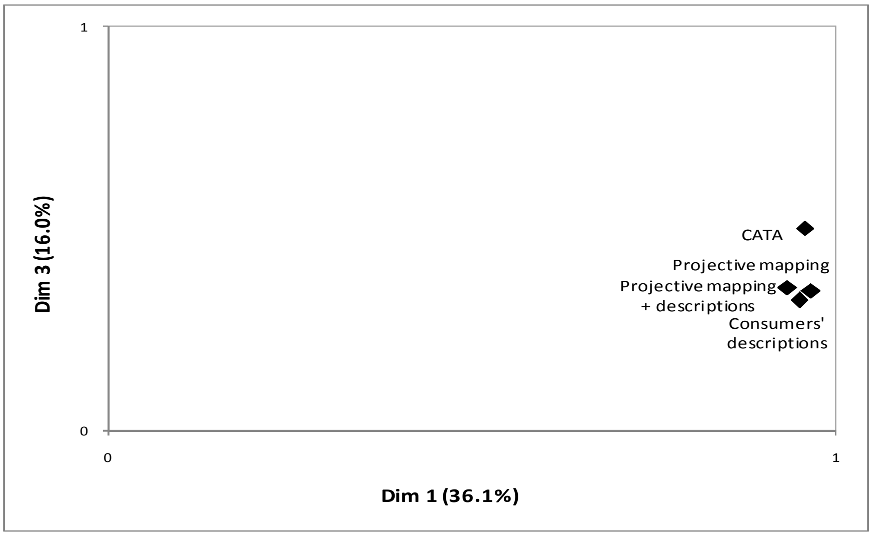


Figure 5.11. Representation of the groups of methods used to obtain the sensory profile of the desserts in the first three dimensions of the hierarchical multiple factor analysis.

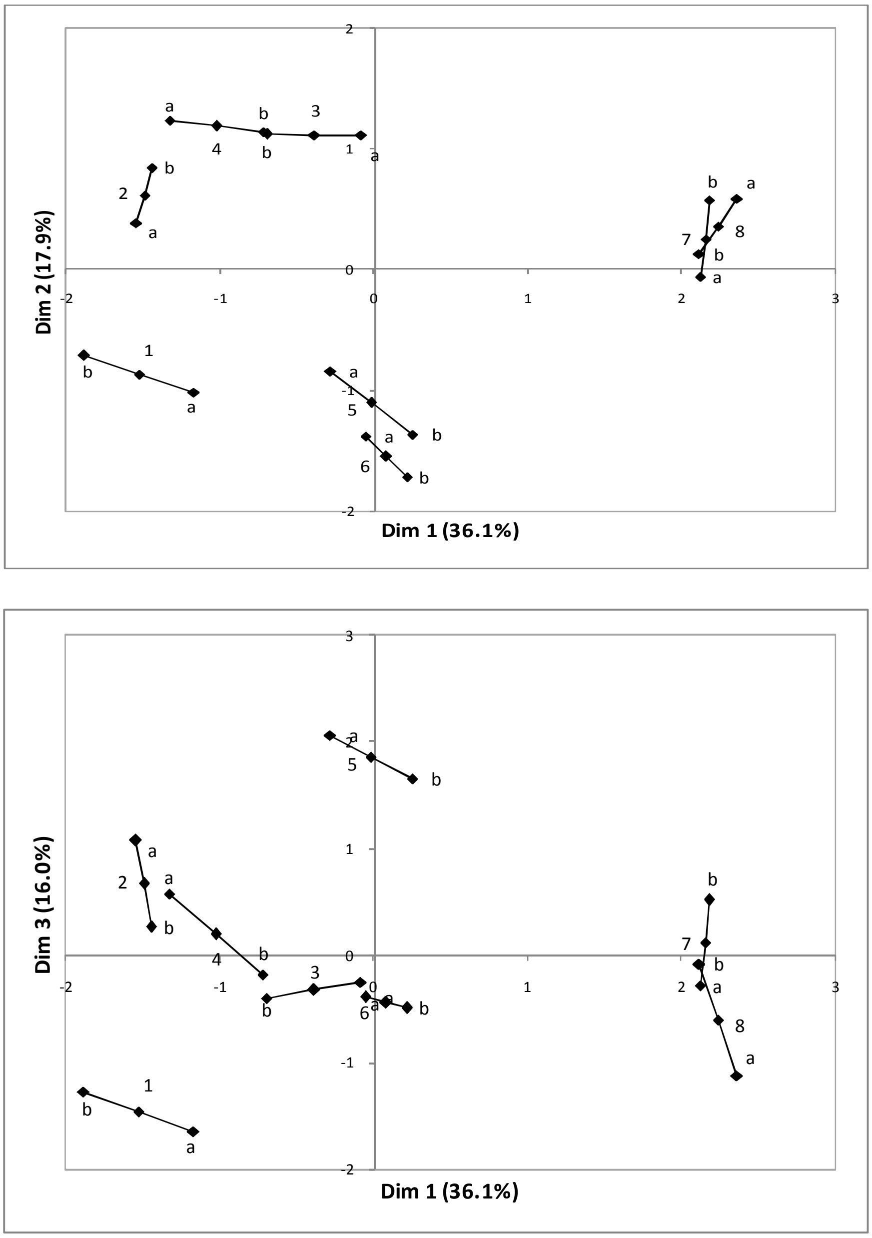


Figure 5.12. Superimposed representation of the samples in the hierarchical multiple factor analysis. Each dessert is represented using three points corresponding to each method: a) CATA and b) projective mapping and consumers' descriptions. The mean point of the two methods is the middle point which took into account both methodologies.

5.2.2.6. External preference mapping

An external preference mapping was carried out considering the samples' coordinates in the first two dimensions of the consensus representation of the HMFA of results from the projective mapping task and CATA counts. As shown in Figure 5.13, none of the samples was located in the region of maximum liking. This is in agreement with the fact that the mean overall liking was close to 6. The most liked samples (i.e. samples 3, 5, 7 and 8) were located close to the contour line that indicate 50% of consumers scoring overall liking higher than 6, as shown in Figure 5.13.

In this case, the region of maximum liking corresponded to that in which more than 70% of the consumers scored overall liking higher than 6 (c.f. Figure 5.13). As shown, this region was located in an intermediate point between samples 7 and 8, and samples 2, 3, 4. Therefore, an optimum chocolate milk dessert should have intermediate sensory characteristics between these two groups of samples.

Samples 7 and 8 were described as bitter, very thick and intense chocolate flavour, whereas samples 2, 3 and 4 were described as creamy, light, not much sweet and not much thick (c.f. Figures 5.3, 5.4, 5.6 - 5.10). Therefore, the ideal sample should have an intermediate chocolate flavour, thickness, sweetness and bitterness from that of these two groups of samples. Thus, further studies should be carried out to obtain a chocolate milk dessert formulation with these sensory characteristics.

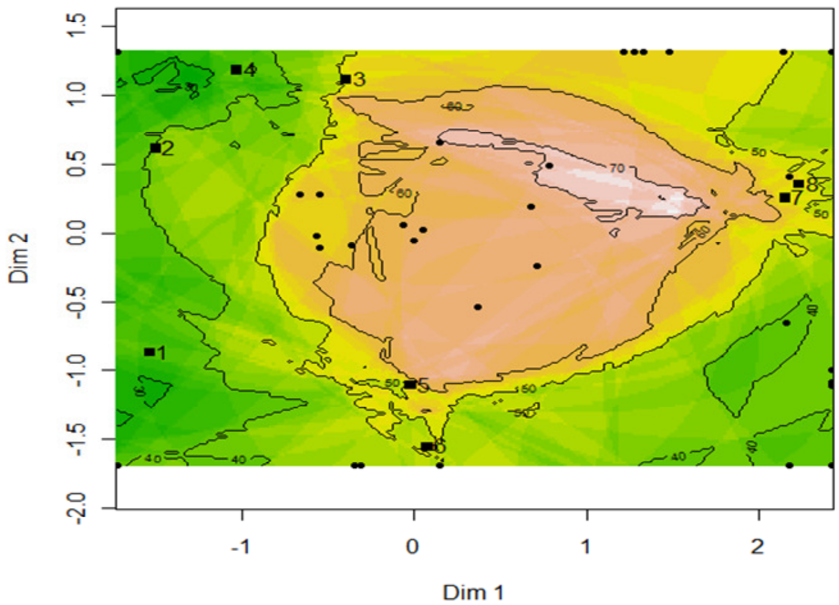


Figure 5.13. External preference map based on consumers' perception of the samples, i.e. considering consensus samples' coordinates in the HMFA of consumers' responses to the CATA question and projective mapping task.

5.2.3. PARTIAL CONCLUSIONS

Projective mapping and a check-all-that-apply question provided a sensory profile of the samples. The perceived differences in the sensory characteristics of the samples were explained by differences in their formulation, which suggests the validity of the sensory profiles given by consumers.

Although differences in the overall liking scores of the samples were small (approximately 1 point in a 9-point hedonic scale) consumers were able to discriminate the samples using both methodologies. This suggests that projective mapping and CATA questions could be useful to evaluate consumers' perception of food products, even when there are no large differences between them.

Responses to the CATA question and consumers' descriptions in the projective mapping task were useful to identify drivers of liking and disliking for the evaluated chocolate milk desserts. The main drivers of liking of the evaluated milk dessert were thickness, chocolate flavour, bitterness and sweetness. The advantage of this approach is that the most relevant sensory attributes that affected consumer perception of the desserts were identified in their own language, without the need of establishing a mathematical relationship with trained assessors' data. One of the questions that arise from these results is how to generate the terms used in the CATA question. One alternative could be to use previous data from open-ended questions or word association tasks.

Although projective mapping and CATA questions do not provide a direct measure of the intensity of sensory attributes, they present some advantages over consumer profiles obtained using scales. Both methodologies could be considered simpler and more natural tasks for consumers than intensity scales and could yield less biased information than just-about-right scales. Information from sensory profiles obtained using consumers' perception could be useful for food companies to develop effective concept and positioning strategies. Particularly, in the last years most companies use consumer input for product development, advertisement, market positioning and communication.

Projective mapping, a CATA question, and consumers' free descriptions consisted on valuable tools to understand consumers' perception of the sensory and hedonic characteristics of the desserts. These methodologies provided very similar results and could consist on useful and interesting complimentary techniques to trained assessors' data. They could consist on a valid alternative to traditional sensory profiles for food companies only when there is not much time or resources available.

External mapping performed on samples' coordinates of the HMFA of data from the projective mapping task and CATA question showed that none of the evaluated samples were located near the region of maximum liking. Therefore, a reformulation of the samples is necessary to obtain a chocolate milk dessert for the development of a functional product. The region of maximum liking was located in an intermediate point between two groups of samples, one group formulated with 3% starch and another group formulated with 2% starch. Furthermore, the main sensory attributes that affected consumers' overall liking scores were thickness, bitterness, sweetness and chocolate flavour. For this reason a second study was performed to optimize cacao and sugar concentration, considering a fixed starch concentration (intermediate between 2% and 3%).

5.3. OPTIMIZATION OF CHOCOLATE MILK DESSERTS FORMULATION

5.3.1. MATERIALS AND METHODS

5.3.1.1. Milk desserts

Two three-level variables were considered in the study: cacao and sugar concentrations. Nine milk desserts were formulated following a response surface design (Gacula, 1993). These two variables were selected considering that sweetness, thickness, chocolate flavour and bitterness were the main sensory attributes responsible for the differences in consumers' overall liking of the desserts evaluated in Section 5.2. Variables and levels are presented in Table 5.8.

Milk desserts were prepared in tap water using 12% powdered skimmed milk (Conaprole, Montevideo, Uruguay), commercial sugar, sweetened powdered cacao (Nestlé, Uruguay) (55% cacao, 45% sugar), 2.4% modified cooked up tapioca starch (National Frigex, National Starch, Trombudo Central, Brazil), and 0.1% sodium tripolyphosphate. The rest of the formulation consisted of water up to 100%.

This formulation was selected based on results from Section 5.2 and preliminary studies. Different preliminary studies were performed to select a formulation that provided chocolate milk desserts with intermediate characteristics between the two groups of samples identified in Section 5.2, i.e. samples 2, 3 and 4, and samples 7 and 8. Polydextrose was not used in the present study since it did not show any influence on overall liking scores. Instead of using cacao, a sweetened cacao was used.

Table 5.8. Ingredient percentage composition of the nine chocolate milk desserts, formulated following a response surface design.

Sample	Cacao	Sugar
1	6	11
2	6	13
3	6	15
4	8	11
5	8	13
6	8	15
7	10	11
8	10	13
9	10	15

Desserts were prepared by mixing the solid ingredients with water and poured into a Thermomix TM 31 (Vorwerk Mexico S. de R.L. de C.V., México D.F., México). The dispersion was heated at 90ºC for 5 min under strong agitation (1100 rpm). The desserts were placed in closed glass containers, cooled to room temperature (25ºC) and then stored refrigerated (4-5ºC) for 24 h prior to their evaluation.

5.3.1.2. Trained assessors panel

The sensory panel consisted of eight trained assessors with previous experience in the evaluation of milk desserts.

In order to generate sensory descriptors, four samples of chocolate milk desserts with different composition, widely differing in their sensory characteristics were presented to assessors. First, assessors were asked to generate their individual descriptors using a modified grid method (Damasio & Costell, 1991). By open discussion with the panel leader, assessors agreed on the best descriptors to fully describe the samples, their definitions and how to evaluate them. The final list of descriptors used for the sensory profile of chocolate milk desserts consisted of five descriptors: sweetness, chocolate flavour, thickness, creaminess and aftertaste. Thickness was defined as 'the thickness of the food in the mouth after being compressed between the tongue and the palate'; whereas creaminess was the 'range of sensations associated with smooth, not rough, with a velvety coating'. Assessors were trained in the evaluation of the abovementioned attributes using desserts with different composition.

Thirty grams of desserts were served in 60-mL odorless plastic containers at 10ºC, codified with three-digit random numbers. A balanced complete block design was carried out for duplicate evaluation of the samples. Unstructured 10-cm-long scales anchored with 'nil' and 'high' were used to describe attribute intensity. The testing was carried out in a sensory laboratory that was designed in accordance with ISO 8589 (ISO, 1988). Evaluations were performed under artificial daylight type illumination, temperature control (between 22 and 24ºC) and air circulation.

5.3.1.3. Consumer study

Seventy consumers, ages ranging between 18 and 63, were recruited from the city of Montevideo, Uruguay. Participants were approximately 50% male and 50% female and were regular milk dessert consumers, since they consumed milk desserts at least once a week.

The nine milk dessert samples were presented to consumers following a balanced and unique order for each participant (MacFie *et al.*, 1989). Twenty grams of desserts were served in 60-mL odorless plastic containers at 10ºC, codified with three-digit random numbers. Water was available for rinsing. The testing was carried out in a sensory laboratory that was designed in accordance with ISO 8589 (ISO, 1988).

For each sample, consumers had to score their overall liking using a 9-point hedonic scale and to answer a check-all-that-apply question with 18 hedonic and sensory attributes that would be appropriate to describe the desserts. The attributes were based on results from a previous study in which consumers used a word association task to describe vanilla milk desserts (Ares *et al.*, 2009b). The evaluation sheet used in the study is shown in Appendix I. The evaluated attributes were the following: sweet, yummy, soft, thick, intense chocolate flavour, vanilla flavour, very creamy, delicious, rough, not much sweet, disgusting, very thick, very sweet, not much thick, not much chocolate flavour, bitter, not much creamy, and creamy.

5.3.1.4. Data analysis

An Analysis of Variance (ANOVA) was carried out on sensory and consumer data considering assessor, cacao, sugar and the interaction cacao*sugar as fixed sources of variation. Mean ratings and honestly significant differences were calculated using Tukey's test, and were considered significant when $p \leq 0.05$.

A principal component analysis (PCA) was also performed on the correlation matrix of the means of the trained assessors' data.

In order to identify groups of consumers with similar preference patterns, a hierarchical cluster analysis was performed on overall liking data. Euclidean distances and Ward's aggregation method were considered.

For the CATA study, frequencies of mention for each word were determined by counting the number of consumers that used that word to describe each milk dessert, and Friedman's test was carried out for each of the terms, considering sample and consumer as sources of variation to evaluate if the check-all-that-apply question was able to detect differences in consumers' perception of the evaluated milk desserts,

Multiple Factor Analysis (MFA) is a factor analysis method that deals with data sets composed of both quantitative variables and frequency tables (Bécue-Bertaut *et al.*, 2008; Bécue-Bertaut & Pagès, 2008). A MFA was performed to study the relationship between responses to the CATA question of the whole consumer sample. MFA was also performed on CATA counts and mean scores for the attributes evaluated by the sensory panel. Besides, MFA was performed considering counts for each of the two groups of consumers identified in the cluster analysis.

Finally, external preference mapping was used to link consumer overall liking scores and sensory data. This analysis was carried out as proposed by Danzart *et al.* (2004) using SensoMineR (Lê *et al.*, 2008b) in R language (R Development Core Team 2007). A quadratic response surface was computed per consumer; preference zones were delimited and finally superimposed. The percentage of consumers that liked a product with coordinates x and y on the sensory map were determined. This analysis was carried out separately considering sample coordinates in the PCA of the trained assessors' data and in the MFA of CATA counts.

All statistical analyses were performed using Genstat Discovery Edition 2 (VSN International, Hemel Hempstead, UK) and R language (R Development Core Team, 2007). Multiple factor analysis was carried out using FactoMineR (Husson *et al.*, 2007; Lê *et al.*, 2008a).

5.3.2. RESULTS AND DISCUSSION

5.3.2.1. Trained assessors' data

Highly significant differences ($p<0.001$) between the samples were found for all the evaluated sensory attributes, as shown in Table 5.9.

Table 5.9. Mean intensity[§] for the sensory attributes, evaluated by the trained assessors, for the nine chocolate milk desserts

Sample	Sweetness	Chocolate flavour	Thickness	Creaminess	Aftertaste duration
1	5.9 ^{b}	4.4 ^{a}	3.3 ^{a}	4.3 ^{a}	4.0 ^{a}
2	6.8 ^{c}	5.6 ^{b}	4.4 ^{b}	4.9 ^{a,b}	5.0 ^{b}
3	7.8 ^{d}	5.7 ^{b}	4.9 ^{b}	5.6 ^{c}	5.7 ^{c}
4	5.4 ^{b}	6.0 ^{b}	5.0 ^{b}	5.9 ^{c,d}	6.2 ^{c,d}
5	5.8 ^{b}	6.7 ^{c}	5.9 ^{c}	6.3 ^{d,e}	5.8 ^{c,d}
6	7.1 ^{c}	6.9 ^{c}	6.2 ^{c}	4.8 ^{a,b}	6.4 ^{d}
7	4.5 ^{a}	8.4 ^{d}	8.0 ^{d}	6.6 ^{e}	8.4 ^{f}
8	4.6 ^{a}	8.5 ^{d}	7.8 ^{d}	5.4 ^{,b,c}	7.7 ^{e}
9	6.0 ^{b}	8.3 ^{d}	8.9 ^{e}	5.5 ^{b,c}	7.1 ^{e}

Different letters within a column imply significant difference according to Tukey's test ($p<0.05$). [§] evaluated in 10cm unstructured scales.

Both cacao and sugar concentration had a significant effect on the sensory profile of the desserts (c.f. Table 5.10). As expected, increasing sugar concentration resulted in an increase of sweetness, chocolate flavour and thickness. Meanwhile, chocolate flavour, thickness, creaminess, and aftertaste increased and sweetness decreased when cacao concentration increased.

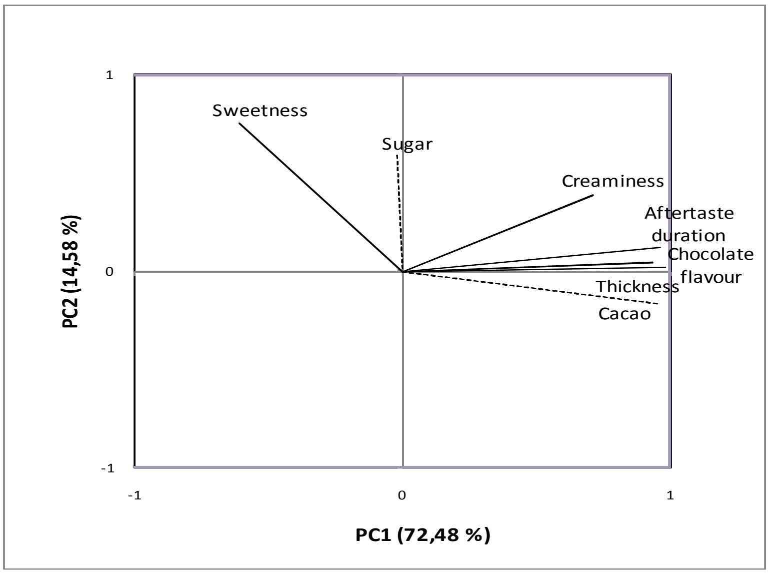
Table 5.10. F-ratios in the ANOVA of the trained assessors' data.

Attribute	**Factor**		
	Sugar	**Cacao**	**Sugar*Cacao**
Sweetness	39.4***	53.0***	5.2***
Chocolate flavour	5.9**	213.6***	4.3***
Thickness	14.4***	635.1***	6.8***
Creaminess	1.24^{ns}	14.1***	14.5***
Aftertaste duration	1.25^{ns}	107.6***	10.8***

*** indicates a significant effect ($p \leq 0.001$), ** ($p \leq 0.01$), whereas ^{ns} indicates no significant effect ($p>0.05$).

A principal component analysis (PCA) was performed on the trained assessors' data. The first two principal components (PCs) accounted for by 72.5% and 14.6% of the variance of the experimental data, respectively. As shown in Figure 5.14, the first PC was positively correlated to chocolate flavour, thickness, creaminess and aftertaste. Therefore, this PC was mainly related to the sensory attributes that were affected by cacao concentration, which could be seen by projecting cacao concentration on the first two PCs (c.f. Figure 5.14). On the other hand, the second PC was related to sweetness, being the main sensory attribute affected by sugar concentration.

(a)



(b)

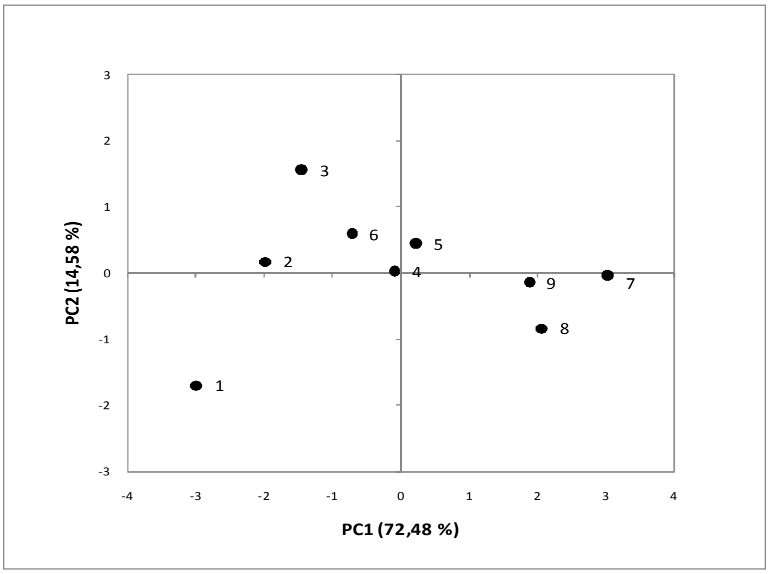


Figure 5.14. PCA of the trained assessors' data: **(a)** representation of sensory attributes and design factors as supplementary variables, **(b)** representation of the samples.

This analysis indicated that cacao had a larger effect on the sensory characteristics of the milk desserts than sugar, in agreement with results from ANOVA (c.f. Table 5.10).

Samples were sorted according to their cacao and sugar concentrations, as shown in Figure 5.14. Samples manufactured with 8 and 10% of cacao (1-6) were mainly grouped according to their cacao concentration, suggesting that sugar concentration did not have much influence on their sensory characteristics. On the other hand, samples with the lowest cacao concentration were separated in PC2 according to their sugar concentration (1-3). Therefore, the influence of sugar on the sensory characteristics of the desserts depended on the cacao concentration considered, in agreement with the significant interaction found between these two variables for all the evaluated sensory attributes.

5.3.2.2. Consumer overall liking scores

The mean overall liking scores of the evaluated samples ranged from 5.6 to 7.1, as shown in Table 5.11, and significant ($p<0.001$) differences were found between samples. Products 5 and 7 showed the highest liking scores, whereas samples 1, 2 and 6 showed the lowest.

As shown in Table 5.12, sugar did not significantly ($p>0.05$) affect consumer overall liking scores, whereas cacao and the interaction cacao*sugar had a highly significant effect ($p<0.001$). This is in agreement with the fact that cacao introduced the largest changes in the sensory profile of the milk desserts. The significant effect of the interaction sugar*cacao suggests that the influence of sugar concentration on consumers' overall liking scores depended on the cacao concentration being considered.

On average, samples with 10% cacao showed the highest overall liking, whereas no significant differences were found between samples with 6% and 8% cacao (c.f. Table 5.11).

Table 5.11. Mean consumers' overall liking§ scores of the nine evaluated milk desserts

Sample	Mean overall liking
1	$6.1^{b,c}$
2	$6.1^{b,c}$
3	6.5^{b}
4	6.3^{b}
5	$6.6^{a,b}$
6	5.6^{c}
7	7.1^{a}
8	6.3^{b}
9	6.4^{b}

Different letters imply significant difference according to Tukey's test ($p<0.05$). § evaluated in a 9-point hedonic scale.

Table 5.12. F-ratios in the ANOVA of consumers' overall liking scores.

Variable	Factor		
	Sugar	**Cacao**	**Sugar*Cacao**
Overall liking	2.0^{ns}	3.8*	5.4***

*** indicates a significant effect ($p\leq0.001$), ** indicates a significant effect ($p\leq0.01$), whereas ^{ns} indicates no significant effect ($p>0.05$).

5.3.2.3. Check-all-that-apply question

Table 5.13 shows the frequency in which each of the terms of the check-all-that-apply question was used to describe the evaluated milk desserts. The most frequently used terms were 'sweet', 'intense chocolate flavour', 'yummy', 'thick' and 'soft'. Meanwhile, the least used term was 'disgusting'; in agreement with the fact that the lowest mean overall liking score was 5.6.

Significant differences were found in the frequencies in which 13 out of the 18 terms of the CATA question were used to describe samples (c.f. Table 5.13). Significant differences were found for the terms related to the texture and flavour of the desserts. This suggests that this type of question was able to detect differences in consumers' perception of the chocolate milk desserts.

Table 5.13. Results of the check-all-that-apply question. Frequencies in which each word was mentioned for each the evaluated samples.

Attribute	Sample								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Sweet *	41	39	44	30	40	33	31	26	33
Yummy ^{ns}	28	28	35	26	40	29	36	31	30
Soft ***	38	34	31	31	28	29	15	20	16
Thick ***	20	15	23	38	44	43	35	24	20
Intense chocolate flavour ***	19	15	26	34	38	36	53	44	46
Vanilla flavour ^{ns}	11	10	10	5	6	11	8	3	4
Very creamy *	19	21	16	13	6	15	10	13	19
Delicious ^{ns}	9	4	14	8	10	9	13	5	10
Rough ***	10	9	6	6	13	13	24	18	24
Not much sweet *	10	8	6	16	10	6	11	18	9
Disgusting ns	8	8	4	0	5	4	1	4	4
Very thick ***	0	3	1	10	10	15	25	40	40
Very sweet ***	5	13	11	8	9	5	6	4	4
Not much thick ***	24	23	19	6	5	8	3	1	0
Not much chocolate flavour ***	28	20	13	15	9	9	4	10	6
Bitter ***	9	13	13	21	15	18	33	34	28
Not much creamy ^{ns}	13	11	6	5	3	14	9	10	13
Creamy ***	24	30	33	29	29	23	24	18	14

*** indicates significant differences ($p \leq 0.001$), ** indicates significant differences ($p \leq 0.05$), whereas ^{ns} indicates no significant differences ($p > 0.05$).

No significant differences were found for the terms ‘yummy’, ‘delicious’ and ‘disgusting’, which could be related to the relatively small differences in the samples’ overall liking scores.

As shown in Table 5.13, samples 1, 2 and 3 were mostly described using terms as ‘not much thick’, ‘sweet’, ‘not much chocolate flavour’ and ‘creamy’, and is on agreement with the fact that these samples contained the lowest cacao concentration. On the other hand, samples with the highest cacao concentration (7, 8 and 9) were described using words such as ‘intense chocolate flavour’, ‘yummy’, ‘sweet’, ‘thick’, ‘very thick’, ‘rough’ and ‘bitter’.

Multiple factor analysis was carried on out on CATA counts, considering overall liking scores as supplementary variables. The first three dimensions of the MFA accounted for by 79.8% of the variance of the experimental data, representing 54.1%, 15.3% and 10.3% of the variance respectively. As shown in Figure 5.15, the first dimension of the MFA was positively correlated to the terms ‘very thick’, ‘rough’, ‘not much sweet’, ‘bitter’ and ‘intense chocolate flavour’; and negatively to the terms ‘soft’, ‘not much thick’, ‘sweet’, ‘delicious’ and ‘not much chocolate flavour’. On the other hand, the second dimension was negatively correlated to the term ‘thick’ and positively correlated to the term ‘disgusting’. The rest of the terms from the CATA question were correlated to the bisectors of the first and second quadrant of the representation of the first two dimensions of the MFA. The bisector of the first quadrant of the representation of the first two dimensions of the MFA was positively correlated to the term ‘not much creamy’ and negatively correlated to the terms ‘yummy’ and ‘creamy’; whereas the bisector of the second quadrant contrasted positively with the term ‘very creamy’. Moreover, the third dimension of the MFA was positively correlated to the term ‘very sweet’ but did not provide much different information from that obtained using the first two dimensions.

As discussed in Section 5.2, the terms with the quantitative adjective ‘very’ were negatively correlated with the terms with the quantitative expression ‘not much’, suggesting that the use of these terms was related to the intensity. Therefore, CATA questions may provide information about attribute intensity.

As shown in Figure 5.15, the terms ‘yummy’ and ‘delicious’, as well as overall liking scores, were positively correlated to the terms ‘sweet’, ‘creamy’ and ‘soft’, suggesting that these sensory attributes were drivers of liking. On the opposite, the term ‘disgusting’ was negatively correlated to the term ‘thick’, indicating that thickness was an important attribute in determining consumers’ hedonic impression of the desserts.

Figure 5.16 shows the representation of the nine desserts in the first three MFA dimensions. This representation closely resembles in the PCA of the trained assessors’ panel (c.f. Figure 5.14). As shown, the first dimension sorted the desserts according to their cacao concentration, in agreement with the fact that this dimension was correlated to chocolate flavour intensity. On the other hand, the second dimension mainly sorted the desserts according to their sugar concentration. The third dimension of the MFA did not provide much information.

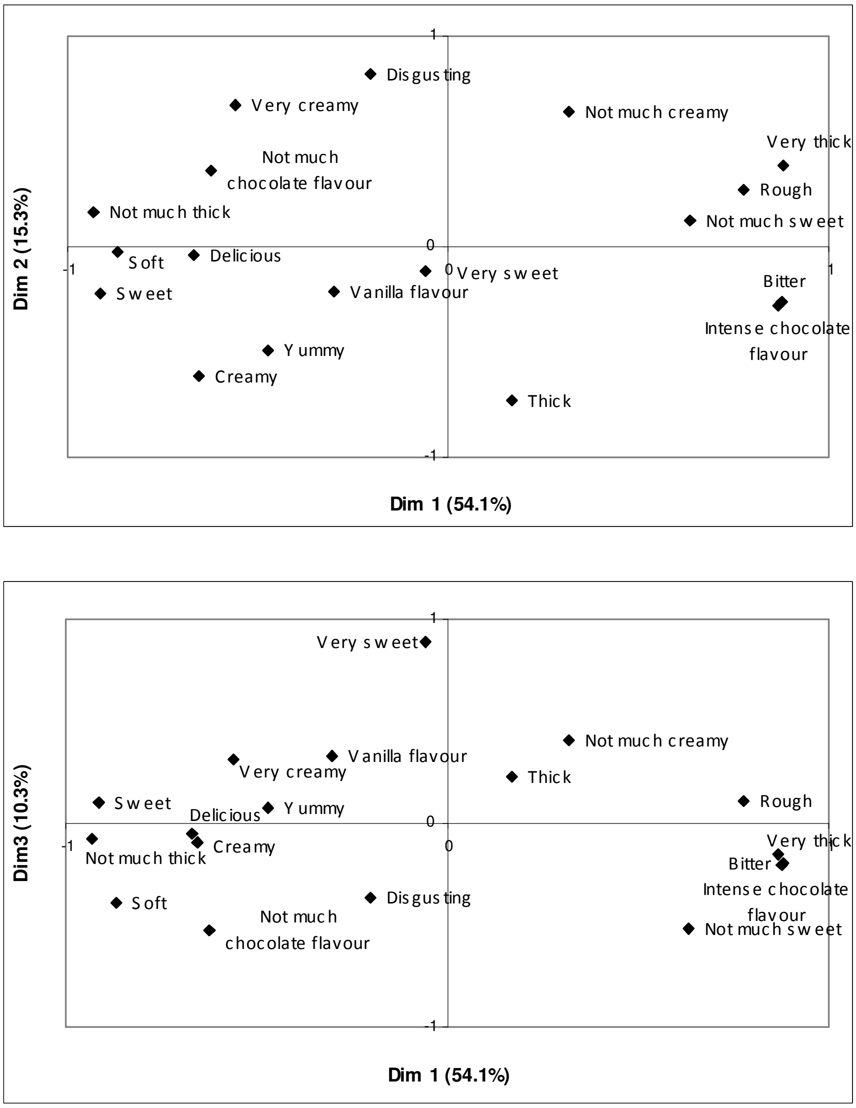
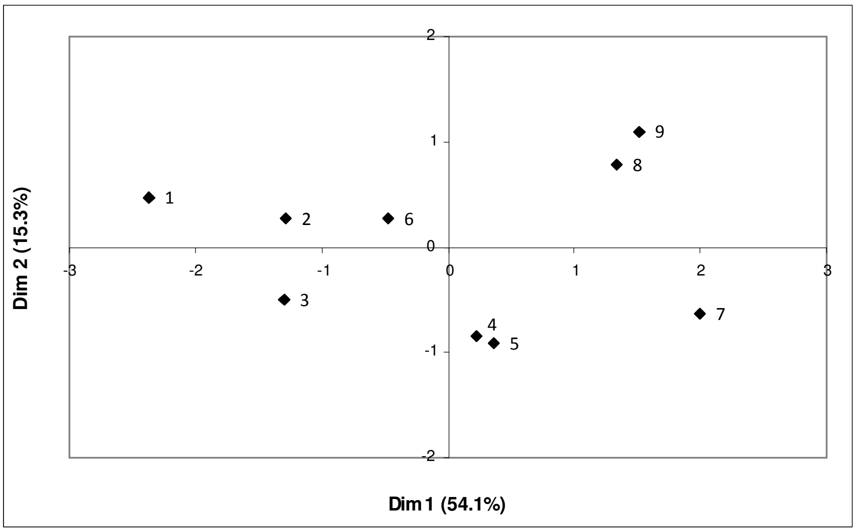


Figure 5.15. Representation of sensory and hedonic terms on the first three dimensions of the multiple factor analysis of CATA counts.



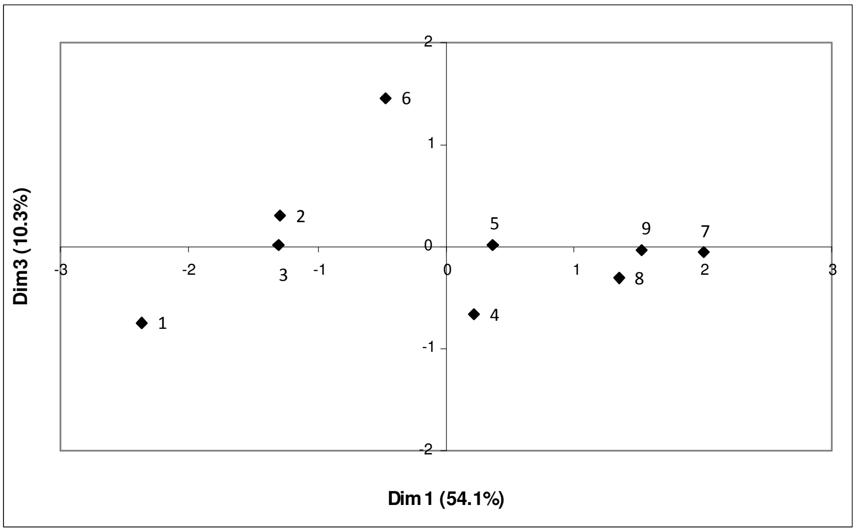


Figure 5.16. Representation of the nine chocolate milk desserts on the first three dimensions of the multiple factor analysis of CATA counts.

According to results from the MFA, the main differences between the sensory characteristics of the samples could be attributed to their cacao concentration. Samples 1, 2 and 3, formulated with the lowest cacao concentration, were located to the left side of the first dimension. These desserts were described as soft, sweet, not much thick and having not much chocolate flavour. On the other hand, samples 7, 8 and 9 were located to the right side of the first dimension of the MFA; in agreement with the highest cacao concentration of those samples. These three desserts were described as very thick, bitter, not much sweet, rough and having an intense chocolate flavour. Moreover, samples 4, 5 and 6 were located in an intermediate position of the first dimension.

Considering the correlation of the terms 'yummy' and 'delicious' with the first dimension of the MFA, samples 1, 2 and 3 would be the most preferred, which is not in agreement with their overall liking scores, suggesting, consequently, the existence of segments of consumers with different preference patterns.

In order to evaluate the relationship between consumers' and trained assessors' sensory profile, a MFA was carried out considering two data sets: CATA counts and means scores for the evaluated sensory attributes. The first two dimensions of the MFA accounted for by 74.9% of the variance of the experimental data, representing 56.5% and 18.4% of the variance, respectively. CATA counts and trained assessors' data contributed to a balanced inertia of the first dimension of the MFA (49.8% and 50.2%, respectively); whereas CATA counts showed a greater influence than trained assessors' data on the second dimension inertia (76.9% and 23.1% respectively).

As shown in Figure 5.17, the variable correlation circle showed a good agreement between consumer and trained assessors' data. CATA terms were correlated to their corresponding sensory attribute evaluated by the trained panel. The sensory attribute 'sweetness' was positively correlated to the terms 'sweet' and 'very sweet' from the CATA question and negatively correlated to the term 'not much sweet'. 'Chocolate flavour' as evaluated by the trained panel was positively correlated to 'intense chocolate flavour', and negatively to 'not much chocolate flavour'. The attribute 'very thick' (from CATA question) positively correlated to 'thickness'; whereas 'thick' did not correlate to this sensory attribute. On the other hand, 'creaminess' was negatively correlated with the term 'not much creamy' from the CATA question. These results indicated the good agreement between both types of evaluations and the validity of obtaining a sensory map from consumers' responses to a CATA question.

This suggests that the use of quantitative terms, such as 'very' and 'not much', could provide a better estimation of the intensity of sensory attributes in a CATA question. The use of CATA questions might be easier for consumers than intensity scales and could provide similar information. They could also yield less biased information. Further research is necessary in order to evaluate the usage of CATA questions to estimate attribute intensity as well as the adequacy of sensory attributes.

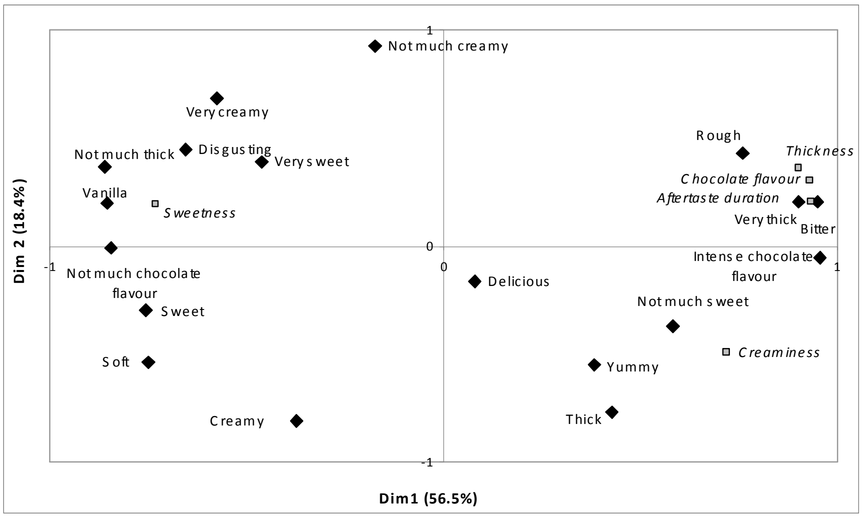


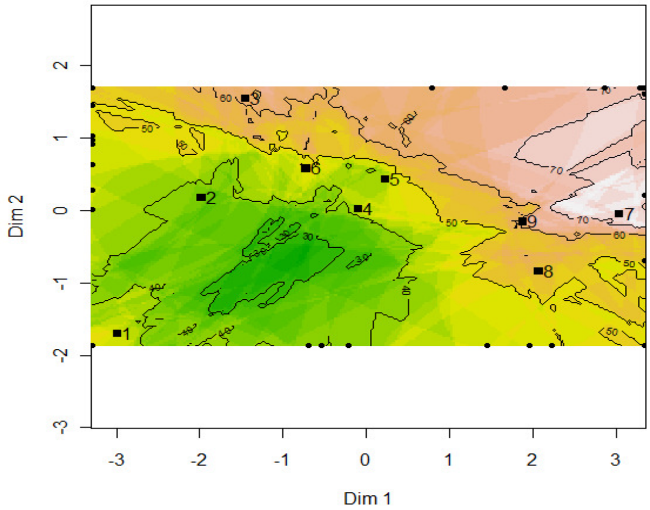
Figure 5.17. Multiple factor analysis of responses to the CATA question (black trapezoid) and trained panel data (gray squares).

5.3.2.4. External preference mapping

Figure 5.18 shows the results of the external preference mapping carried out on consumers' individual overall liking scores, considering samples' coordinates in the first two dimensions of the MFA of the CATA questions, and the first two dimensions of the PCA of the trained panel. The similar findings suggests the expected concordance between the two methodologies, as they yielded similar sensory maps for the evaluated samples.

According to the external preference maps, the area in which sample 7 was located, corresponded to that of maximum liking. In this region more than 70% of the consumers scored their overall liking higher than 6. Therefore, in the studied sensory space, sample 7 corresponded to that with the highest consumers' overall liking, and could be considered the sample with optimum sensory characteristics.

(a)



(b)

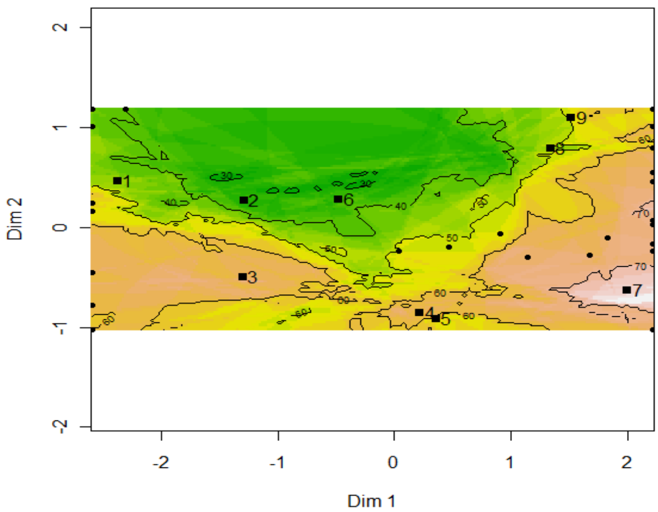


Figure 5.18. External preference map for all consumers considering samples' coordinates in the first two dimensions of: **(a)** the PCA of the trained panel, and **(b)** the MFA of CATA counts

5.3.2.4. Cluster analysis

Using hierarchical cluster analysis, two groups of consumers which scored the overall liking of the samples differently were identified: Cluster 1 with 32 consumers and Cluster 2 with 38 people.

According to ANOVA, cacao concentration and the interaction cacao*sugar significantly affected overall liking scores of the two identified clusters (c.f. Table 5.14). On the other hand, sugar concentration did not significantly ($p>0.05$) affect their overall liking scores.

Table 5.14. F-ratios in the ANOVA of overall liking scores for consumers in each of the two identified clusters.

Cluster	Factor		
	Sugar	**Cacao**	**Sugar*Cacao**
Cluster 1	1.8 ^{ns}	4.7 **	2.5 **
Cluster 2	0.2 ^{ns}	15.5 ***	3.9 ***

*** indicates a significant effect ($p\leq0.001$), and ** ($p\leq0.01$), whereas ^{ns} indicates no significant effect ($p>0.05$).

As shown in Table 5.15, there were significant differences ($p<0.001$) in the clusters' overall liking, indicating different preference patterns. The clusters mainly differed in their attitude towards increasing cacao concentrations. As shown in Table 5.16, consumers in Cluster 1 significantly ($p<0.05$) increased their overall liking scores with decreasing cacao concentrations. On the other hand, consumers in Cluster 2 gave the highest overall liking scores to milk desserts with the highest cacao concentration.

Considering that the two identified clusters showed different preference patterns, they could have also used the terms of the

CATA question differently. Therefore, MFA was carried on out considering CATA counts for both groups of consumers.

Table 5.15. Mean overall liking§ scores of the nine chocolate milk desserts for the two identified clusters

Sample	Overall liking score	
	Cluster 1 (n=32)	Cluster 2 (n=38)
1	6.7^{a,b}	5.5^{d,e}
2	6.7^{a,b}	5.6^{d,e}
3	6.9^{a}	6.1^{c,d}
4	6.2^{a,b,c}	6.4^{c}
5	6.6^{a,b}	6.6^{c}
6	6.1^{b,c}	5.2^{e}
7	6.8^{a,b}	7.3^{a,b}
8	5.8^{c}	6.7^{b,c}
9	5.1^{d}	7.4^{a}

Mean values within a column are significantly different according to Tukey's test ($p<0.05$). § evaluated in a 9-point hedonic scale.

Table 5.16. Mean effect of cacao concentration overall liking scores for consumers in each of the two identified clusters.

Cacao concentration	Mean overall liking score	
	Cluster 1	Cluster 2
6%	6.7^{a}	5.7^{b}
8%	6.3^{a,b}	6.1^{b}
10%	5.9^{b}	7.1^{a}

Mean scores with different superscripts are significantly different according to Tukey's test ($p\leq 0.01$)

The first two dimensions of the MFA accounted for 60.4% of the variance of the experimental data, representing 43.9% and 16.6% of the variance, respectively. CATA counts of both clusters contributed in a balanced way to the inertia of the first (49.9% and

50.1%, respectively) and second dimension (61.2% and 38.8%, respectively).

Figure 5.19. Multiple factor analysis of the CATA question considering responses for each Cluster as active data sets. Representation of words for Cluster 1 (black trapezoid) and Cluster 2 (gray squares)

As shown in Figure 5.19, there was a strong correlation between the evaluations of several sensory terms from the CATA question by the two groups of consumers, suggesting that words related to the sensory attributes of the desserts were used similarly by the two clusters, despite their different preference patterns. The terms 'intense chocolate flavour', 'very thick', 'rough', 'very creamy', 'bitter', 'thick', 'creamy', 'soft', 'not much chocolate flavour' and 'not much thick' were correlated for both clusters. Therefore, these sensory attributes were evaluated in a similar way by both groups of consumers. On the other hand, some other sensory terms, such as ‘sweet’, ‘not very sweet’ and ‘not much creamy’, did not show a good correlation, indicating that they were not used in a similar way. Moreover, terms related to hedonic characteristics of the desserts were used differently for both clusters, which could be explained by their different preference patterns, particularly their different preference towards chocolate flavour intensity.

The terms ‘yummy’ or ‘delicious’ were related to the terms ‘not much thick’, ‘sweet’ and ‘not much chocolate flavour’ for consumers in Cluster 1 (black trapezoid), whereas they were related to terms as ‘bitter’, ‘intense chocolate flavour’, ‘rough’, ‘very thick’ and ‘not much sweet’ for consumers in Cluster 2 (grey squares) (c.f. Figure 5.19). Therefore, both clusters had different drivers of liking, which reflects the differences in their preference patterns. Consumers in Cluster 1 preferred bitter and intense chocolate milk desserts, whereas consumers in Cluster 2 preferred sweet milk desserts with not much chocolate flavour. These results show the importance of segmentation when identifying drivers of liking, since consumers with different preference patterns like different sensory characteristics in a food product.

The samples’ positions (c.f. Figure 5.20) and the correlation of the hedonic terms of the CATA question for the two identified clusters enabled the identification of their preference patterns. Samples 1, 2 and 3 were related to the terms yummy and delicious by Cluster 1; and samples 7, 8 and 9 were related to the same terms by consumers in Cluster 2.

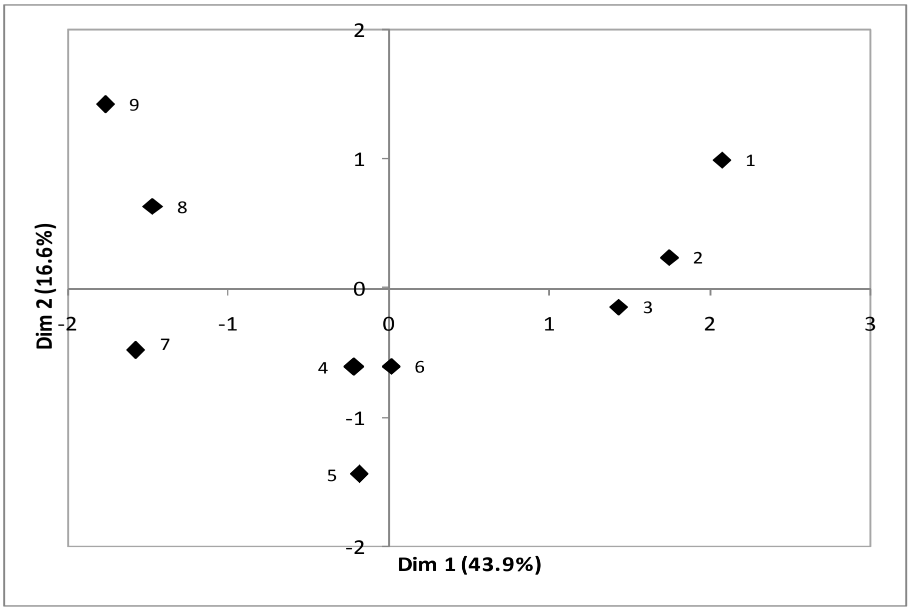
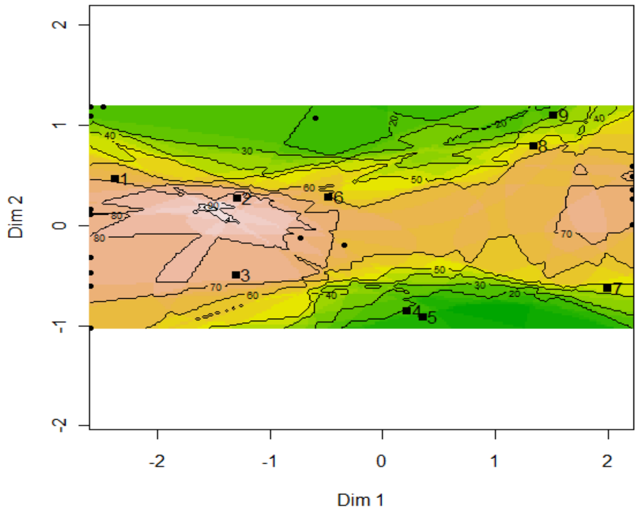


Figure 5.20. Multiple factor analysis of the CATA question considering responses for each Cluster as active data sets. Representation of the nine chocolate milk desserts.

The abovementioned differences in the preference patterns of the two groups of consumers could be also visualized in the external preference maps performed taking into account the samples' coordinates in the first two dimensions of the MFA of CATA counts, as shown in Figure 5.21. In the case of Cluster 1 the optimum product corresponded to a dessert with sensory characteristics intermediate of samples 1, 2 and 3; whereas for consumers in Cluster 2 the optimum product was similar to samples 8 and 9.

(a)



(b)

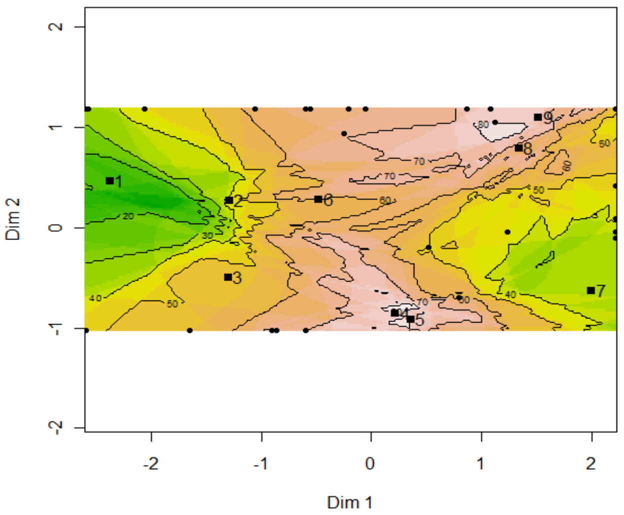


Figure 5.21. External preference map for all consumers considering samples' coordinates in the first two dimensions of the MFA of CATA counts for consumers in: **(a)** Cluster 1, and **(b)** Cluster 2.

Samples 1, 2 and 3 were formulated with the lowest cacao concentration; whereas samples 8 and 9 were formulated with the highest cacao and sugar concentration. These results are in agreement with those previously discussed. Consumers in Cluster 1 preferred soft and sweet chocolate milk desserts with a low chocolate flavour intensity and not much thick. On the other hand, consumers in Cluster 2 liked desserts with the opposite sensory characteristics, i.e. thick, bitter chocolate milk desserts with high chocolate flavour intensity and low sweetness.

Sample 7 was identified as the best sample when external preference mapping was performed on CATA counts for the whole consumer sample. Although this sample was not the most liked for any of the identified consumer segments, it could be considered a good compromise between their opposite preference patterns. If only one sample should be selected, sample 7 seems the most appropriate since its sensory characteristics are a good compromise between the sensory characteristics preferred by consumers in both clusters.

5.3.3. PARTIAL CONCLUSIONS

The sensory map generated using multiple factor analysis on CATA counts was very similar to the samples' representation on the PCA of the trained assessors' data. This suggests that the use of a CATA question could consist on a complementary technique to traditional preference mapping techniques or an alternative when no trained assessors' panel is available.

Groups of consumers with different preference patters evaluated the sensory characteristics of the milk desserts similarly as they used words from the CATA question in the same way. This suggests that consumers mainly took into account their perception of the sensory characteristics of the desserts rather than their likes or dislikes when deciding to check an item related to the sensory characteristics of the desserts. On the other hand, the clusters differed in how they use hedonic terms, as expected. This enabled the identification of drivers of liking for both groups of consumers.

In this study only sensory and hedonic terms were considered but words related to concept deliverables and occasion of use could be also used (Adams *et al.,* 2007). Therefore, samples could be characterized in terms of not just sensory attributes but also considering consumer perception of different aspects of the samples.

Using the sensory map from the MFA of the CATA external preference mapping could be carried out to link consumer overall liking scores with their perception of the sensory characteristics of the samples. This approach could provide complimentary information for food companies regarding consumer perception of the sensory characteristics of food products.

Although two groups of consumers with opposite preference patterns were identified, sample 7 was identified as the optimum chocolate milk dessert in the range of sensory characteristics considered. This sample showed one of the highest overall liking scores and, according to the external preference map, could be considered as a good compromise between the preference patterns of the two identified consumer segments.

5.4. GENERAL CONCLUSIONS

Considering results from the present chapter, the use of projective mapping tasks, open-ended or check-all-that-apply questions consist on interesting and simple methodologies to get an insight on consumer perception of food products. Using these methodologies a map of the samples could be generated based only on consumer perception of the products. Also, they could be a simple way to perform external preference mapping when a sensory trained panel is not available or when there is not enough time to train a sensory panel.

These methodologies also showed the advantage that consumers provide both hedonic and sensory terms to describe the samples. Therefore, they enabled the identification of liked and disliked samples, as well as the sensory attributes responsible for consumers' preferences. This might outcome one of the drawbacks of traditional mapping techniques, i.e. that trained assessors could describe the product differently or take into account attributes that may be irrelevant for consumers. Therefore, by using these methodologies the sensory characteristics of the samples are described by considering just consumer perception.

Sweetness, thickness and chocolate flavour could be regarded as the most important sensory attributes that affect consumers' preferences of this type of dairy product. Although two consumer segments with different preference patterns were identified, a formulation of a chocolate milk dessert that showed good consumer acceptance was identified. This formulation was used as base product for the development of chocolate milk desserts enriched with antioxidant extracts; which is the subject of the following chapter.

CHAPTER 6

DEVELOPMENT OF CHOCOLATE MILK DESSERTS ENRICHED WITH ANTIOXIDANT EXTRACTS

ABSTRACT

The aims of the present chapter were to identify consumers' expectations of chocolate milk desserts enriched with antioxidants; to study their perception of chocolate milk desserts enriched with a water extract from *Achyrocline satureoides;* and to determine if consumers' previous expectations affected product perception.

Seventy five consumers participated in the study. First, participants were asked to complete a word association task. Then, consumers tried six milk desserts with different polyphenolic concentration and indicated their overall liking and willingness to purchase. Consumers were also asked to provide up to four words to describe each of the samples.

In the word association task consumers mainly elicited terms related to health and sensory characteristics of the desserts. Thus, consumers mainly expected the chocolate milk desserts they like to positively affect their health. The addition of a water extract from *Achyrocline satureoides* caused a significant decrease ($p<0.05$) in consumers' overall liking and willingness to purchase, due to increasing off-flavour and herb flavour caused by the addition of the extract. Therefore, consumers were not willing to tolerate these sensory changes for eventual long-term health benefits. Considering overall liking scores, the maximum concentration of the antioxidant extract from *Achyrocline satureoides* to be added to chocolate milk desserts corresponded to a polyphenolic concentration of 0.4 g/L. This product could reach an interesting market since a relatively high proportion of consumers chose it over a regular chocolate milk dessert. Cluster analysis performed on consumers' elicited terms in the word association task allowed

the identification of three consumer segments with different expectations and motivations to purchase chocolate milk desserts enriched with antioxidants. These groups also differed in their evaluation of the desserts when tasting them; showing different overall liking, willingness to purchase, and sensory description of the samples. According to these results, word association could be a simple technique to understand consumer expectations before trying a product, and to study how these expectations affect their response after trying the product; being particularly interesting when novel products are considered. Consumer segmentation based on their previous expectations could help to assure that a product meets consumer expectations appropriately, leading to a higher satisfaction.

6.1. INTRODUCTION

As discussed in Chapters 2 and 3, health-related issues have been identified as the main reason for consumer acceptance of functional foods. Consumers can only be expected to consider consuming functional foods if they are perceived as healthier than their conventional counterparts (Urala and Lähteenmäki, 2003). However, consumers' acceptance of functional foods does not only depend on their interest in health. Sensory characteristics have been reported to be one of the main determinants of acceptance (Childs & Poryzees, 1997; Poulsen, 1999; Gilbert, 2000; Tuorila & Cardello, 2002; Verbeke, 2006; Huotilainen *et al.,* 2006; Siró *et al.*, 2008; Ares *et al.*, 2009a; Sabbe *et al.*, 2009a; 2009b).

In order to gain the health benefits derive from functional foods consumption, consumers need to include them as part of their usual diet for a relatively long period of time (Sarubin, 2000), and consequently the sensory properties of functional foods should not discourage sustained consumption. The addition of many functional ingredients results in the appearance of off-flavours that decreases the sensory quality of the product (Urala & Lähteenmäki, 2004).

On the other hand, Reineccius (2000) has reported that functional food consumers are committed to the health benefits of these products and might be willing to have a food product with an unpleasant taste. Juttelstad (1998) stated that the presence of off-flavours in functional foods could be expected and considered as a marker of the health benefit of the product. Thus, the perception of an off-flavour could support and strengthen the health message.

According to a study on muffins enriched with different types of fibre, consumers might expect an off-flavour in a functional food, and could be more confident with the product and its health benefits if they perceive the referred off-flavour (Baixauli *et al.,* 2009). These authors reported that when consumers tried a fibre-enriched muffin similar to a regular one they reacted as they did not believe the fibre content was similar to that enriched with a bran-type fibre. In consequence, when consumers try a food product enriched with a certain functional ingredient, they might expect to find certain sensory characteristics from that ingredient.
On the other hand, several authors have stressed that consumers are hardly willing to compromise on the taste of functional foods for eventual health benefits (Gilbert, 2000; Tuorila & Cardelo, 2002; Cardello & Schutz, 2003; Cox *et al.*; 2004; Verbeke, 2006; Ares *et al*., 2009a). Hilliam (2003) indicated that one of the challenges faced by the functional food industry is developing functional foods with an acceptable taste to the average consumer. Besides, Tuorila & Cardello (2002) stated that the occurrence of off-flavours (bitter/salty) decreased the overall liking and probability of consumption despite the presence of convincing health claims. These decreases in overall liking and willingness to consume occurred regardless of the type of health benefit considered and even when the off-flavour was present at a minimal intensity. Moreover, Ares *et al.* (2009a) reported that consumers were not able to tolerate the sensory changes caused by the addition of resistant starch to milk puddings. According to Verbeke (2006), the development of functional foods that taste worse than regular

products is highly speculative, risky and deemed to yield a niche market strategy for food companies.

Therefore, during the development of functional foods it is extremely important to identify consumers' expectations before they try the product. Once their expectations are identified, it is necessary to study what are the changes in the sensory characteristics of the product as a consequence of the addition of the functional ingredient, and how consumers react to these changes. These aspects are crucial for assuring consumer acceptance of new functional foods.

Expectations affect people everyday reactions and decisions both consciously and subconsciously (Deliza & MacFie, 1996). In food science, expectations can be defined as pre-trial beliefs about a product (Olson & Dover, 1979). There are two types of expectations: sensory-based and hedonic-based expectations (Cardello, 1994). Sensory expectations are related to consumers' beliefs about the sensory characteristics of the product. On the other hand, the latter are related to beliefs about how much they will like/dislike the product (Cardello, 1994). Therefore, before testing a product, consumers have an idea of what its sensory characteristics might be and how much they would like or dislike it. These expectations are created through consumers' previous experiences, information and the product itself. High expectations will likely lead to the consumer choosing the product, whereas low expectations will lead to product rejection (Cardello, 1994). After choosing the product, it is tasted and the expected sensory and hedonic characteristics are compared with the real ones; leading to confirmation or disconfirmation (Deliza & MacFie, 1996). A mismatch between expected and actual sensory or hedonic characteristics of the product would lead to positive or negative disconfirmation, depending if the product is better or worse than expected, respectively (Cardello, 1994). If negative disconfirmation occurs, the consumer will probably reject the product and do not buy it again (Deliza & MacFie, 1996). Therefore, in order to assure consumer acceptance, manufacturers should gather information about what they expect from their products; being particularly important in the case of novel products.

The aims of the present work were to: **(a)** identify consumers' expectations of chocolate milk desserts enriched with antioxidants, **(b)** study consumers' perception of chocolate milk desserts enriched with a water extract from *Achyrocline satureoides*, and **(c)** determine if consumers previous expectations about chocolate milk desserts enriched with antioxidants influenced their perception.

6.2. MATERIALS AND METHODS

6.2.1. Antioxidant extract

A water extract from *Achyrocline satureioides* (Marcela) was obtained as described in Section 4.2.1.3. Dried leaves from *Achyrocline satureioides* were obtained from a local retailer (La Botica del Señor, Montevideo, Uruguay).

The total polyphenolic content (PP) of the extracts was determined using Folin–Ciocalteau reagent (Singleton *et al.*, 1984), as described in Section 4.2.1.5.

6.2.2. Chocolate milk desserts

The base formulation for the development of milk desserts enriched with antioxidant extracts was selected considering results from Chapter 5. Milk desserts were prepared in tap water using 12% commercial powdered skimmed milk, 11% commercial sugar, 10% sweetened powdered cacao (Nestlé, Uruguay), 2.4% modified cooked up tapioca starch (National Frigex, National Starch, Trombudo Central, Brazil), 0.1% sodium tripolyphosphate and antioxidant extract from Achyrocline satureioides. The rest of the formulation consisted of water up to 100%.

Six milk desserts containing different antioxidant extract concentrations were formulated. The evaluated antioxidant extract concentrations corresponded to the following total polyphenolic contents: 0, 0.4, 0.6, 0.8, 1.2 and 1.6 g/L. These contents were selected considering the polyphenolic content of beverages commonly consumed in Uruguay, with well-known antioxidant capacity, such as tea and mate (Bravo et al. 2007) and results from Chapter 4.

Desserts were prepared by mixing the solid ingredients with water and poured into a Thermomix TM 31 (Vorwerk Mexico S. de R.L. de C.V., México D.F., México). The dispersion was heated at 90ºC for 5 min under strong agitation (1100 rpm). Then, the antioxidant extract was added to the desserts and mixed under strong agitation (1100 rpm) for 2 min. The desserts were placed in glass containers, closed, cooled to room temperature (25ºC) and then stored refrigerated (4-5ºC) for 24 h prior to their evaluation.

6.2.3. Consumer study

Seventy five consumers, ages ranging between 18 and 63, were recruited from the city of Montevideo, Uruguay. Participants were approximately 50% male and 50% female and were regular milk dessert consumers as they consumed this product at least once a week.

Before the evaluation, consumers completed a word association task. They were asked to write down the first four images, associations, thoughts or feelings that came to their minds when thinking of a chocolate milk dessert enriched with antioxidants. Participants were also asked to indicate their expected liking of this type of dessert using a 9-point hedonic scale.

After this, consumers were told that they were going to try a regular chocolate milk dessert and five samples of chocolate milk desserts enriched with antioxidants. The six samples were presented to consumers following a balanced order for each participant (MacFie *et al.*, 1989). Twenty grams of desserts were served in 60-mL odorless plastic containers at 10ºC, codified with three-digit random numbers and the term ‘regular chocolate milk dessert’ or ‘chocolate milk dessert enriched with antioxidants’. Thus, during the evaluation consumers knew if they were trying a regular chocolate milk dessert or one enriched with antioxidants. For each sample, consumers had to indicate their overall liking using a 9-point hedonic scale and their willingness to purchase the desserts using a 9-point structured scale labelled on the left with ‘I would definitively not buy it’ and on the right with ‘I would definitively buy it’. An open-ended question was used to gather information about consumers’ perception of the sensory characteristics of the milk desserts (Ares *et al.*, 2009b). Consumers were asked to provide up to four words to describe each of the desserts in terms of sensory characteristics. Finally, consumers were asked to indicate which of the six desserts they would buy. The evaluation sheet used in this study is shown in Appendix J. Water was available for rinsing the mouth between samples. The testing was carried out in a sensory laboratory that was designed in accordance with ISO 8589 (ISO, 1988).

6.4. Data analysis

The elicited terms in the word association task were qualitatively analyzed. First, a search for recurrent terms was performed. Terms with similar meaning were grouped into different categories. This classification was performed independently by three researchers considering personal interpretation of the meaning of the words and word synonymy as determined by a Spanish dictionary. After individually evaluating the data, a meeting of the researchers was undertaken in order to check the agreement between their classifications. The final categories and their names were determined by consensus between the three researchers considering their three independent classifications and discussion between them. Frequencies in each category were determined by counting the number of consumers that used those words. Categories mentioned by more than 10% of the consumers were considered.

In order to identify consumers who elicited similar terms, hierarchical cluster analysis was performed on participants' data. Manhattan distances and Ward's aggregation method were considered. Chi-square was calculated for evaluating differences between clusters' descriptions; whereas for evaluating differences in the clusters' expected liking scores, ANOVA was carried out considering cluster as fixed source of variation. ANOVA was also carried out on overall liking and willingness to purchase scores considering cluster, sample and their interaction as fixed sources of variation.

Mean ratings and honestly significant differences were calculated using Tukey's test, and were considered significant when $p \leq 0.05$.

The elicited descriptions in the open-ended question were qualitatively analyzed as for the word association task. Categories mentioned by more than 10% of the consumers for at least one of the samples were considered. Frequencies in each category were determined by counting the number of consumers that used those words to describe each of the milk desserts. This analysis was performed for the whole studied population and for each of the three clusters identified in the word association task.

A Multiple factor analysis (MFA) was performed considering the number of mentions of the terms for the whole consumer sample as active variables and overall liking and willingness to purchase scores as supplementary variables. MFA was also performed on the data table juxtaposing the frequency tables of the three clusters. This analysis was performed using FactoMineR (Husson *et al.*, 2007; Lê *et al.*, 2008a) in R language (R Development Core Team, 2007).

6.3. RESULTS AND DISCUSSION

6.3.1. Responses to the word association task and expected liking scores

In the word association task participants elicited an average of 2.7 terms. The minimum number of terms elicited was one and the maximum seven. There were 12 categories mentioned by more than 10% of the participants. Table 6.1 shows the final association categories and the frequency in which they were mentioned.

Participants' associations when thinking of a chocolate milk dessert enriched with antioxidants were related to health, sensory and hedonic characteristics. These results are in agreement with those reported in Section 2.3, and confirm that consumers perception of functional foods is related to health-related issues as well as to the sensory characteristics of the product.

As shown in Table 6.1, the most frequent term mentioned by consumers was related to the health benefits of antioxidants, suggesting that health might be the main driver of consumer interest in consuming a functional chocolate milk dessert. This result agrees with results from Chapter 2 and those reported by Urala & Lähteenmäki (2003), and Krystallis *et al.* (2008).

Despite the fact that a functional milk dessert was considered, most of the elicited terms were related to consumers' sensory and hedonic expectations related to the dessert. This is aligned with results from Chapter 2, and those from previous studies which reported that consumer sensory expectations play an important role in consumer perception and choice of functional foods (Tuorila & Cardello, 2002; Urala & Lähteenmäki, 2003; Verbeke, 2006; Krystallis *et al.*, 2008).

Consumers expected a chocolate milk dessert enriched with antioxidants to be sweet, thick, creamy and yummy. These results indicate that sensory and hedonic expectations might be a crucial factor for the acceptance of functional foods as consumers might not be willing to compromise taste for health. Thus, functional ingredients should be added to food products without changing their sensory characteristics. However, a group of consumers associated the addition of antioxidants with the presence of off-flavour in the desserts. This has been already reported in Section 2.3 for yogurts enriched with antioxidants and could decrease consumers' interest in purchasing this type of product.

Table 6.1. Association categories and frequency of mentions in the word association task performed previously to the evaluation, for all consumers (n=75).

Category	Frequency (%)
Healthy	42
Sweet	30
Yummy	30
Off flavour	24
Creamy	21
Interesting	20
Prevention of diseases	18
Nutritious	13
Thick	12
Tasty	11
Soft	11
Beneficial	10

The mean expected liking score was 6.4. This relatively low expected liking score could be related to the fact that some consumers expected some off-flavour due to the addition of antioxidant extracts to the milk dessert.

6.3.2. Consumer overall liking and willingness to purchase scores

The mean overall liking and willingness to purchase scores of the evaluated chocolate milk desserts are shown in Table 6.2. The addition of the antioxidant extract resulted in a significant ($p<0.001$) decrease in consumers' overall liking and willingness to purchase scores. The addition of the antioxidant extract to a polyphenolic concentration of 0.4 g/L led to a decrease of 1.6 and 1.7 points in overall liking and willingness to purchase scores. Increasing polyphenolic concentrations resulted in a decrease in overall liking and willingness to purchase scores until the concentration reached 0.8 g/L. Polyphenolic concentrations higher than 0.8 g/L did not cause a further reduction in overall liking and willingness to purchase scores, as shown in Table 6.2.

Table 6.2. Mean overall liking and willingness to purchase scores for chocolate milk desserts enriched with different concentrations of polyphenolic compounds.

Polyphenolic concentration (g/L)	Overall liking§	Willingness to purchase§
0	7.3 ^{a}	7.1 ^{a}
0.4	5.7 ^{b}	5.4 ^{b}
0.6	4.6 ^{c}	4.1 ^{c}
0.8	4.2 ^{c,d}	3,5 ^{c,d}
1.2	3.8 ^{d}	3.1 ^{d}
1.6	3.8 ^{d}	3.2 ^{d}

Different superscripts indicate significant differences ($p\leq0.05$) according to Tukey's test. § evaluated in a 9-point scale varying from 1 to 9.

Muñoz *et al.* (1992) considered an overall liking score of 6.0 in a 9-point hedonic scale (the first score in the liking category) as commercial or quality limit. Therefore, considering this criterion a chocolate milk dessert containing a polyphenolic concentration higher than 0.4 g/L would not be acceptable. However, the mean overall liking and willingness to purchase scores of this dessert were not very high, suggesting that further studies should be carried out to minimize the influence of the addition of the extract on the sensory characteristics of chocolate milk desserts.

Although consumers knew that the chocolate milk desserts enriched with polyphenolic compounds contained antioxidants, they decrease their overall liking scores with respect to the regular dessert. This suggests that consumers did not tolerate the sensory changes caused by the addition of the antioxidant extract and decreased their overall liking scores. Tuorila & Cardello (2002) and Tuorila *et al.* (1998) reported that health claims might have only a small impact on consumers' pleasantness but they could enhance their interest in consuming and willingness to purchase functional foods. In the present study the mean overall liking and willingness to purchase followed a similar trend, i.e. consumers decreased both scores as the antioxidant extract concentration increased in chocolate milk desserts. It suggests that consumers' awareness of the presence of antioxidant extracts was not enough for fulfilling their sensory and hedonic expectations, leading to a decrease in their willingness to purchase. Tuorila & Cardello (2002) and Sabbe *et al.* (2009a; 2009b) working on off-flavours in juice, and Ares *et al.* (2009a) for the addition of resistant starch to vanilla puddings, reported a decrease on willingness to consume, despite the presence of convincing health claims. These authors suggested that consumers are hardly willing to compromise sensory characteristics of functional foods for eventual or long-term health benefits.

Consumers were faced with the decision of choosing a regular chocolate milk dessert and not very liked products with a beneficial health effect. When asked which of the six chocolate milk desserts they would buy, only 6% of the consumers indicated that they would buy none of the products, as shown in Table 6.3. Thirty-eight and forty percent of the consumers chose the regular chocolate milk dessert and the dessert enriched with 0.4 g/L of polyphenolic compounds respectively. The other desserts enriched with antioxidants were selected in a much lower frequency, following similar pattern than their overall liking and willingness to purchase.

Table 6.3. Percentage of consumers choosing each of the chocolate milk desserts with different polyphenolic concentration.

Polyphenolic concentration (g/L)	Percentage of consumers (%)
0	38
0.4	40
0.6	11
0.8	1
1.2	1
1.6	3
None	6

Although the milk dessert with a polyphenolic concentration of 0.4g/L reached a low overall liking and willingness to purchase score, it was similarly chosen to the regular dessert. This suggests that a relatively high proportion of consumers would buy a milk dessert enriched with antioxidants; despite they do not like it as much as a regular one. This shows the importance of health-related issues to consumers' intention to purchase concerning functional foods.

6.3.3. Consumer descriptions in the open ended question

Table 6.4 shows the terms used by consumers to describe the evaluated chocolate milk desserts. The main terms were related to sensory and hedonic characteristics of the desserts. The most frequent terms were 'bitter', 'off-flavour', 'creamy' and 'disgusting'.

Table 6.4. Categories and frequency mentioned in the open-ended question by consumers to describe the chocolate milk desserts with different polyphenolic concentrations.

Category	Number of mentions
Bitter	126
Off-flavour	88
Creamy	87
Disgusting	77
Intense flavour	54
Sweet	52
Yummy	51
Thick	44
Soft	43
Chocolate flavour	42
Tasty	34
Herb flavour	30
Burnt	27
Rough	22

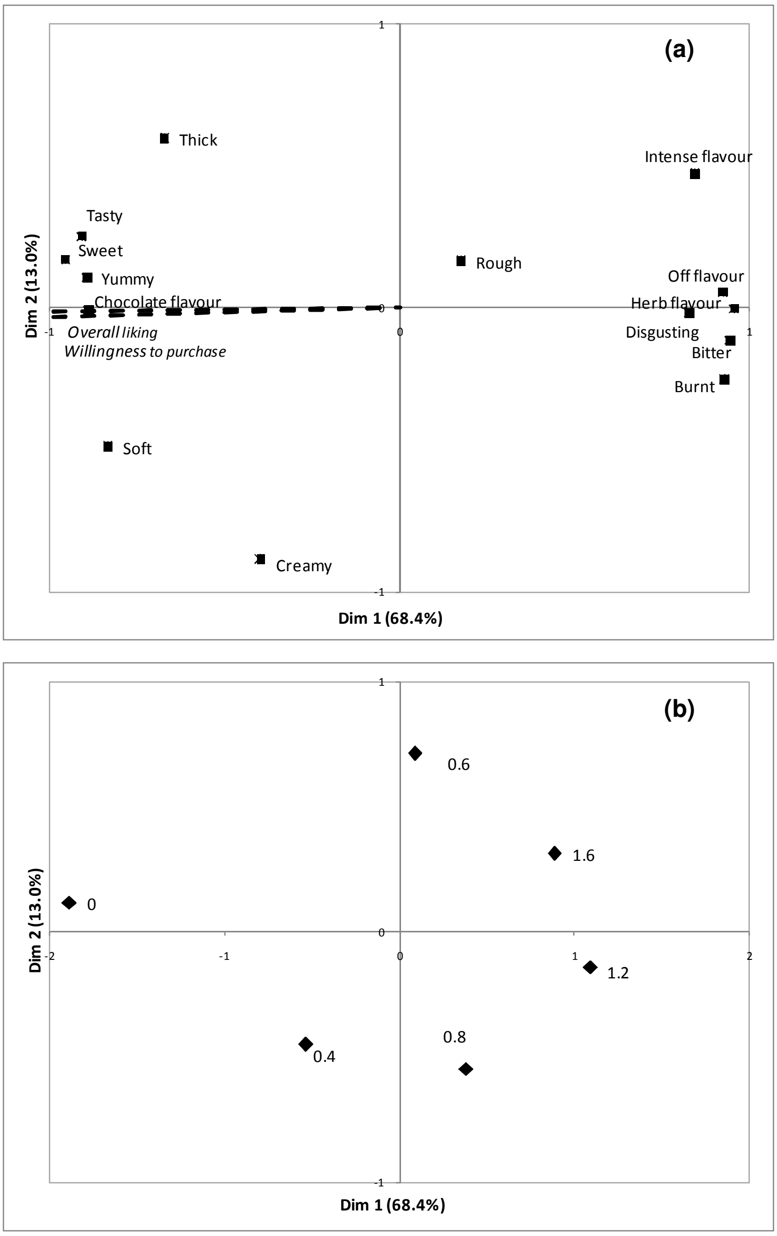
These terms reflect consumer negative reaction towards the sensory changes caused by the addition of the antioxidant extract to the desserts. Although consumers were aware of the fact that most of the milk desserts contained antioxidants, they did not use any health-related term to describe them. When consumers thought of a milk dessert enriched with antioxidants before the evaluation, the most frequently used terms were related to health. This did not happen when consumers tried the desserts, since they elicited only sensory and hedonic terms. This indicates the importance of sensory and hedonic aspects in consumers' perception of functional foods.

As shown in Table 6.5, the regular milk dessert was described using sensory terms like 'bitter', 'creamy', 'sweet', 'thick', 'soft¡' and 'chocolate flavour', and positive hedonic terms such as 'yummy' and 'tasty'. This is in agreement with the relatively high mean overall liking and willingness to purchase scores of this sample (c.f. Table 6.2). On the other hand, consumers used terms such as 'bitter', 'off-flavour', 'intense flavour' and 'herb flavour' to describe the milk desserts containing the antioxidant extract, indicating that the addition of the extract to the dessert caused an increase in bitterness and off flavour, typical in the native plant from which it was extracted. These changes in the sensory characteristics of the desserts have caused a decrease in the product overall liking and willingness to purchase. Therefore, alternatives to reduce the characteristic flavour of the extract, such as different deodorization techniques, should be studied.

Table 6.5. Percentage of consumers that mentioned each of the terms for the evaluated chocolate milk desserts enriched with different polyphenolic concentrations.

Category	**Polyphenolic concentration (g/L)**					
	0	**0.4**	**0.6**	**0.8**	**1.2**	**1.6**
Bitter	17	21	25	33	36	35
Off-flavour	3	12	25	25	31	21
Creamy	21	25	13	23	20	13
Disgusting	3	17	19	17	24	23
Intense flavour	7	8	15	12	13	17
Sweet	24	9	13	11	4	8
Yummy	28	12	13	7	5	3
Thick	16	9	16	4	8	5
Soft	16	16	7	12	4	3
Chocolate flavour	19	9	11	9	7	1
Tasty	15	12	7	3	3	7
Burnt	4	5	5	7	8	7
Herb flavour	0	5	9	8	12	5
Rough	3	8	7	1	7	4

A Multiple factor analysis (MFA) was carried out to visualize the relationships between the terms and the evaluated milk desserts. The first and second dimensions of the MFA explained 68.4% and 13.0% of the variance of the experimental data, respectively (Figure 6.1a). There was a strong correlation between the terms ‘chocolate flavour’, ‘soft’, ‘yummy’, ‘tasty’, ‘sweet’ and the mean overall liking and willingness to purchase, which suggests that these sensory attributes were drivers of liking for consumers. These terms were negatively correlated to the first dimension of the MFA.



Samples are identified according to the polyphenol concentration, expressed in g/L.

Figure 6.1. MFA on the milk desserts open-ended-task by consumers: **(a)** attributes' position, and **(b)** samples' position.

On the other hand, the terms ‘off flavour’, ‘herb flavour’, ‘bitter’, ‘burnt’ and ‘disgusting’ were positively correlated to the first dimension of the MFA, and also negatively correlated to overall liking and willingness to purchase scores; which suggests that they were drivers of disliking for the evaluated milk desserts enriched with antioxidants.

Except for the negative correlation between the term ‘creamy’ and the second dimension of the MFA, there were no clear relationships between this dimension and the sensory and hedonic terms used by consumers to describe the desserts.

As shown in Figure 6.1b, the desserts were sorted in the first dimension of the MFA according to their polyphenolic concentration. The regular milk dessert was located on the left of the first dimension, being described as ‘yummy’, ‘sweet’, ‘tasty’ and having ‘chocolate flavour’.

On the other hand, samples containing the highest concentration of antioxidant extracts were located on the right of the same dimension. These samples were mainly described as ‘bitter’, ’off-flavour’, ‘disgusting’ and ‘herb flavour’, in agreement with their low overall liking scores. Sample containing the lowest polyphenolic concentration (0.4 g/L) was mainly described as ‘soft’ and ‘creamy’.

6.3.4. Cluster analysis

Cluster analysis was carried out to identify groups of consumers who provided similar associations in the word association task about a chocolate milk dessert enriched with antioxidants. Three groups of consumers were identified: Cluster 1 composed of 26 participants, Cluster 2 with 32 participants, and Cluster 3 having 17 consumers. These three clusters significantly differed (χ^2 = 107.7, $p<0.001$) in the terms elicited in the word association task (Figure 6.2),suggesting that these groups might have different associations and expectations regarding a chocolate milk dessert enriched with antioxidants.

As shown in Figure 6.2 participants in Cluster 1 elicited mainly sensory and hedonic expectations of the desserts. On the other hand, participants in Cluster 2 seemed to associate the dessert with health-related terms and also the term 'interesting'. However, participants in this cluster mentioned the term 'off-flavour', indicating that they expect to find some non-characteristic flavour in the desserts due to the addition of antioxidants. The terms related to the sensory characteristics of the desserts were not mentioned with a high frequency by this cluster. Finally, participants in Cluster 3 mentioned both sensory and health related terms. This cluster expected to find a healthy dessert that they would like. These results suggest that expectations for consumers in Cluster 1 were mainly related to sensory and hedonic characteristics; Cluster 2 and 3 gave a higher importance to health and to the positive influence of antioxidants on health. Sensory characteristics were not mentioned by a high proportion of consumers for these clusters.

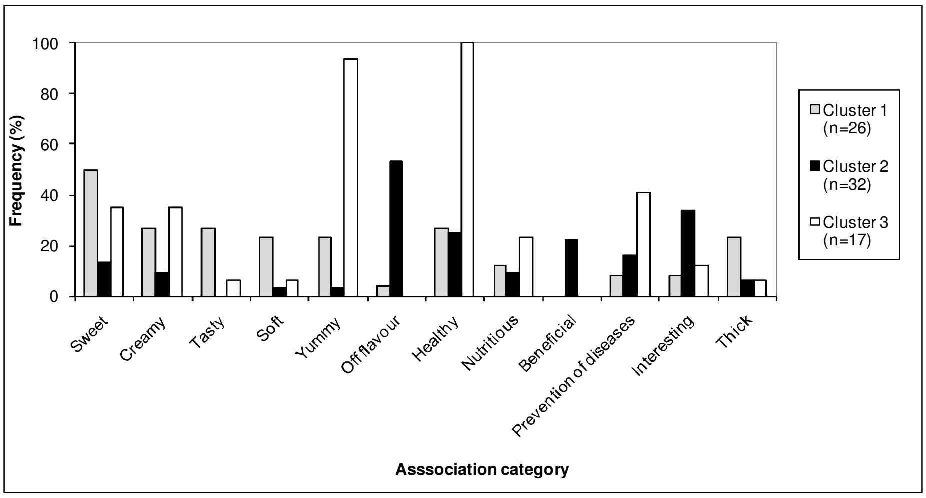
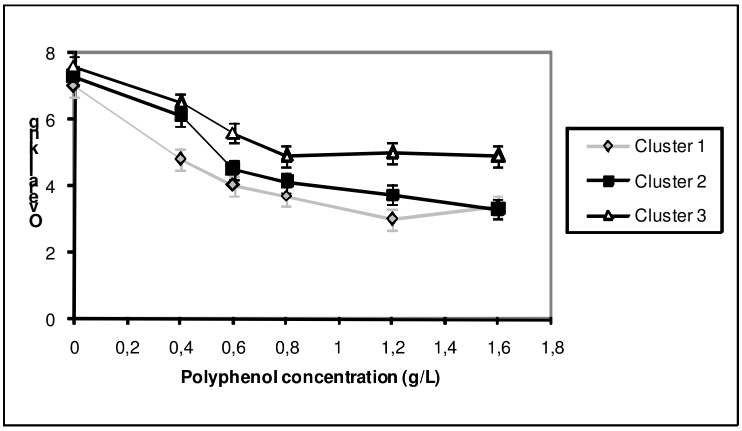


Figure 6.2. Frequency in which each category for the word association task was mentioned for the three identified clusters.

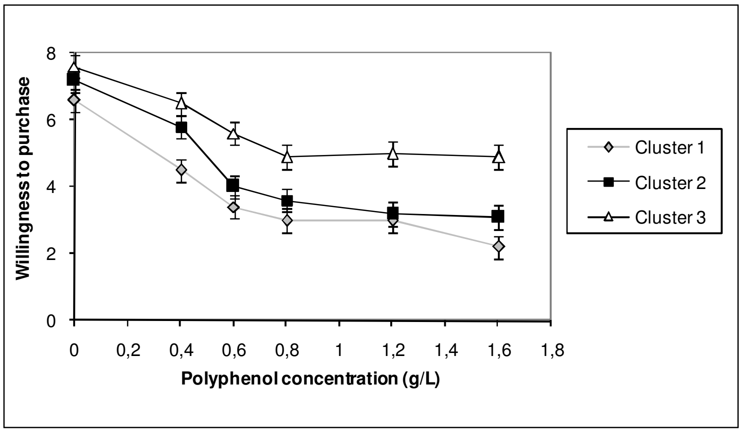
The clusters also significantly differed in their expected liking. Clusters 1 and 3 showed the highest expected liking, 6.5 and 7.0, respectively, which is aligned with the high frequency in which sensory and hedonic terms were elicited. On the other hand, the expected liking for consumers in Cluster 2 was 5.9, significantly ($p<0.05$) lower than Cluster 1 and 3. This could be explained considering that these consumers expected to find some off-flavour when trying the dessert.

These groups of consumers also reacted differently when tasting the desserts. ANOVA indicated that sample and custer significantly ($p<0.001$) affected consumers' overall liking. The interaction sample*custer was not significant, indicating that differences between custers' scores were similar for all the evaluated samples.

(a)



(b)



Vertical bars represent Tukey's honestly significant differences (p<0.05).

Figure 6.3. (a) Mean overall liking, and **(b)** willingness to purchase scores of chocolate milk desserts enriched with antioxidant extracts for the three clusters identified in the word association task.

Consumers in Cluster 1 gave the lowest scores to the overall liking of the desserts, followed by consumers in Cluster 2 and finally consumers in Cluster 3. As show in Figure 6.3, whereas mean overall liking score for the milk dessert containing a polyphenolic concentration of 0.4 g/L was 4.5 for consumers in Cluster 1, Clusters 2 and 3 scored its overall liking using scores close to 6. A similar trend was found for all the samples, suggesting that Cluster 1 was the least tolerant to the sensory changes caused by the antioxidant extract, whereas consumers in Cluster 3 seemed to tolerate them much more. Willingness to purchase scores showed a similar trend to overall liking scores, as shown in Figure 6.3.

Consumers that mainly expected positive sensory characteristics and a ‘yummy’ dessert (i.e. consumers in Cluster 1) were disappointed by the desserts enriched with antioxidants as they perceived some ‘herb flavour’ which they did not expect. This could be explained considering the generalized negativity theory that assumes that any discrepancy between expectations and the real product result in consumers perceiving the product less pleasant than if they had no previous expectations (Deliza & MacFie, 1996).

On the other hand, consumers in Cluster 2, who expected some ‘off-flavour’ in the desserts were not disappointed and scored their overall liking higher. Furthermore, consumers in Cluster 3 seemed to care less about the modifications introduced by the antioxidant extracts, maybe because of the high importance they attributed to health when thinking of a functional product.

Differences in the percentage of consumers who intended to buy each dessert were also found between clusters (c.f. Figure 6.4). The percentage of consumers who chose chocolate milk desserts enriched with antioxidants was higher for Cluster 3, followed by

Cluster 2 and finally Cluster 1. These results indicate that the Clusters also differed in the way they were willing to compromise sensory for eventual health benefits. Consumers more interested in the health effect of antioxidants (i.e. consumers in Cluster 2 and 3) chose to buy desserts enriched with antioxidants over regular ones with a higher frequency than those more interested in the sensory characteristics of the desserts (Cluster 1).

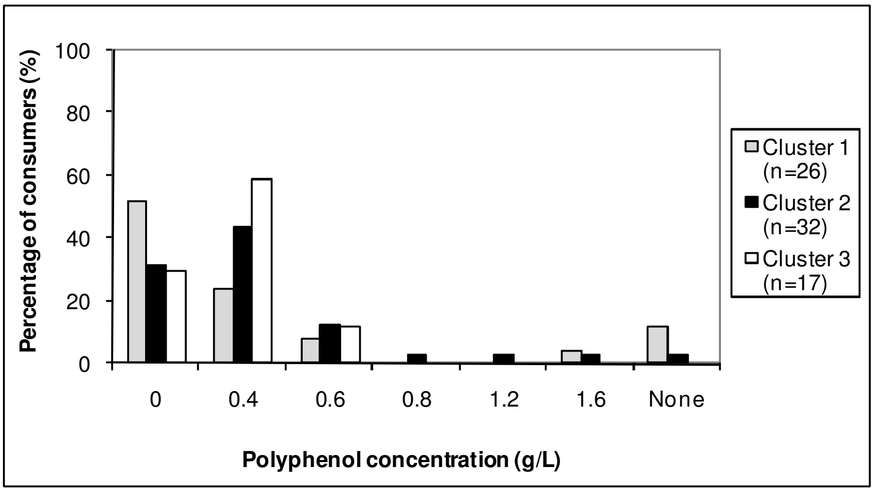
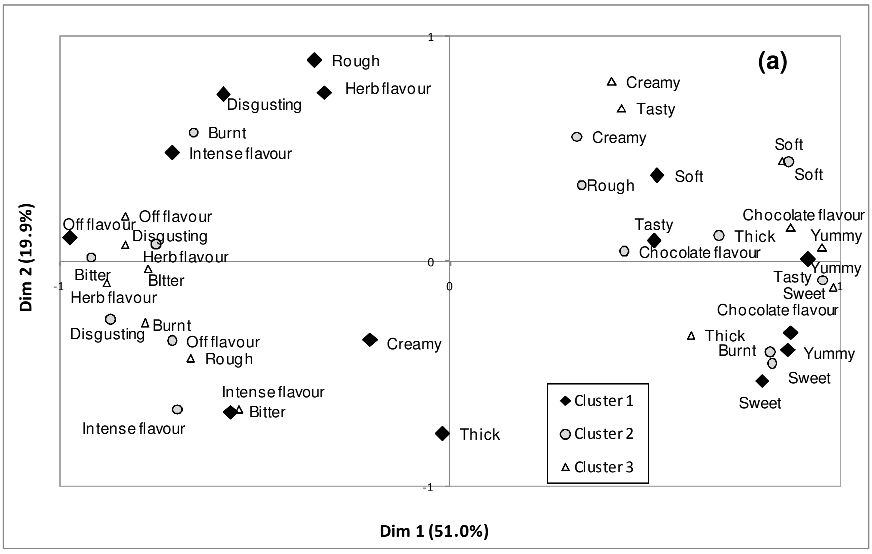


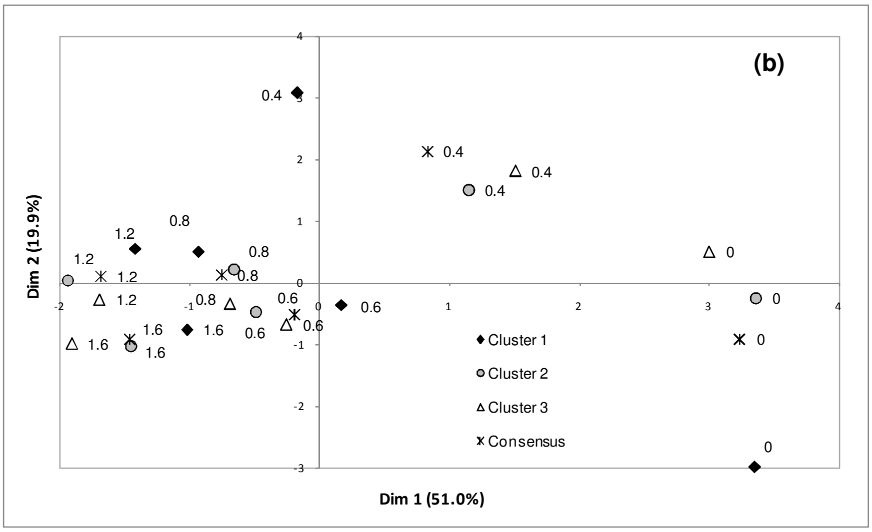
Figure 6.4. Chocolate milk desserts' intention to purchase by cluster of consumer.

In order to evaluate if the identified clusters differed in the terms they used to describe the desserts, a Multiple factor analysis (MFA) was carried out on the frequency table containing the descriptions of the three clusters. The first two dimensions of the MFA accounted for by 70.9% of the variance of the experimental data, representing 51.0% and 19.9% of the variance, respectively. Descriptions of the three clusters contributed in a balanced way to the inertia of the first dimension (30.4%, 35.4% and 34.2%, respectively). When the second dimension was considered, descriptions of the first cluster had a higher influence on the inertia of the second dimension than those of the other two clusters. Descriptions of Cluster 1 contributed with 52.7% to the inertia of the second dimension, whereas descriptions of Clusters 2 and 3 contributed to 23.8 and 23.5%, respectively.

Figure 6.5a shows the representation of the terms used by the three clusters in the first two dimensions of the MFA. There was a strong correlation between the terms ‘chocolate flavour’, ‘soft’, ‘yummy’, ‘sweet’ and ‘off-flavour’ for the three clusters, indicating that they were similarly used by consumers in the three consumer segments to describe the desserts. On the other hand, there was no concordance in how the clusters used the terms ‘herb flavour’, ‘disgusting’, ‘burnt’, ‘creamy’, ‘rough’ and ‘intense flavour’. This could be explained by the fact that the clusters perceived the desserts differently and therefore used some terms to describe them in a different way.

Figure 6.5b shows the position of the samples in the first two dimensions of the MFA for each of the three identified clusters and the consensus representation. The desserts were sorted into three groups, according to their polyphenolic concentration.





Samples are identified according to their polyphenol concentration, expressed in g/L.

Figure 6.5. MFA on the open-ended question task: **(a)** Representation of the terms elicited by the three Clusters; **(b)** Position of the samples.

When the dessert containing a polypenolic concentration of 0.4 g/L was considered, consumers in Cluster 1 provided descriptions related to the sensory changes introduced by the antioxidant extract, such as ‘rough’ and ‘herb flavour’. On the other hand, consumers in Clusters 2 and 3 did not give much importance to this flavour and mainly used positive sensory terms such as ‘creamy’, ‘soft’, ‘chocolate flavour’ and ‘tasty’ to describe it. The terms related to the regular milk dessert and the samples with the highest polyphenol concentrations (0.6, 0.8, 1.2 and 1.6 g/L) were used in a similar way by the three clusters. However, there were some other terms that were used differently, suggesting that different expectations also led to different perception of the desserts. Consumers who showed the highest sensory and hedonic expectations (i.e. consumers in Cluster 1) were the least tolerant to the sensory changes caused by the antioxidant extract and detected some off-flavour, even when the extract was added at the lowest concentration. On the other hand, those consumers who gave more importance to health-related issues when thinking of a milk dessert enriched with antioxidants were much more tolerant to the lowest concentrations of the antioxidant extract.

Therefore, results suggested that consumers reacted towards the desserts according to their expectations regarding the characteristics of the functional product. Segmenting consumers according to their expectations prior to testing a food product could consist on an interesting approach. Identifying what consumers expect from a product could be a way of understanding their reactions towards a food product and how the product features could be modified to better meet those expectations. Further study is necessary to evaluate the applicability of this methodology to more complex products and to overcome some of the limitations of the present study, such as the small number of consumers who took part in the study.

6.4. CONCLUSIONS

Word association probed to be a valuable and simple methodology to get an insight on consumer expectations of chocolate milk desserts enriched with antioxidants.

This methodology could be a simple technique to understand consumer expectations before tasting a product and to study how these expectations affect their response when tasting the product. This approach could be particularly interesting when novel products are considered as it could help assuring that consumers expect the product that really is; which could lead to a higher probability of satisfaction.

The addition of an antioxidant extract from *Achyrocline satureoides* to chocolate milk desserts resulted in a decrease in consumers' overall liking and willingness to purchase due to the increasing in off-flavour and herb flavour caused by the addition of the extract

The use of an open-ended question enabled the identification of liked and disliked samples, as well as the sensory attributes that have driven their preferences.

Considering consumer overall liking, 0.4g/L would be the maximum concentration of the antioxidant extract from *Achyrocline satureoides* to be added to chocolate milk desserts. Taking into account that the characteristic flavour of the extract was the main driver of disliking, the deodorization of the extract could be an interesting alternative to reduce the impact on food products.

Chocolate milk desserts enriched with a water extract from *Achyrocline satureoides* could reach a market because a relatively high proportion of consumers chose it over a regular chocolate milk dessert. However, in the present study a small convenient sample was used. Thus, further consumer research should be carried out in order to evaluate the feasibility of launching chocolate milk desserts enriched with an antioxidant extract from *Achyrocline satureoides*.

CONCLUSIONS

CONCLUSIONS

The general objective of the thesis was to apply and study different sensory methodologies in the development of a functional food product. All the methodologies evaluated in the present thesis proved to be extremely useful to achieve a consumer-driven product development process.

Word association and hard laddering were useful in the first stages of food product development to identify relevant attributes to consumers' perception of the product and to understand motives behind their choices within a food category. Moreover, word association was also useful to investigate consumers' expectations of food products and how these expectations affect their perception.

Conjoint analysis was also useful during the first stages of food product development to screen product concepts. Results from this methodology allowed the selection of the most interesting concepts for consumers, i.e. those which have the largest probability of success on the market. By using this approach in a regular basis during food product development working on new products that have low probability of success could be avoided.

The use of projective mapping tasks, open-ended or check-all-that-apply questions consisted on interesting and simple methodologies to get an insight on consumer perception of the sensory and hedonic characteristics of food products. These methodologies could be valid alternatives to gather a sensory map of a group of food products and to perform external preference mapping when a sensory trained panel is not available or when there is not enough time to train a sensory panel. Information from sensory profiles obtained using consumers' perception could be also useful for food companies to develop effective concept and positioning strategies.

The implementation of some of the abovementioned methodologies during the food products development could increase the success of new products.

The present thesis also provided a first insight on Uruguayan consumers' perception of functional foods, who seemed to be very interested in consuming foods that could have a positive effect on their health. However, perception of functional foods was not homogeneous among them. The main factors that determined consumers' willingness to consume functional foods were interest in health and nutrition and nutritional knowledge. Information about the health effects of functional foods seemed essential to attract consumer groups with different attitudes. The use of appropriate health claims and educational campaigns could be an alternative for food companies to assure the success of their products in the marketplace.

The carrier product and the functional ingredient had an important impact on consumers' perception of functional foods. The enrichment of frequently consumed products with fibre or antioxidants seems the most interesting strategy within functional food development for Uruguayan consumers, contributing to positive implications on the health status of the population.

Considering the complex nature of food choice behavior, further studies should be carried out to investigate the influence of non-sensory factors, such as packaging, brand and price, on consumers' acceptance of functional foods, and how they make decisions when buying this type of food products. This information is necessary to define what strategies could be implemented, by both food companies and government, to encourage their consumption.

During the development of functional foods enriched with antioxidant extracts from Uruguayan native plants, the selection and study of the functional ingredient was a key stage. Alternatives to minimize the high bitterness, astringency and characteristic herb flavor of the Uruguayan native plant extracts should be studied considering the base product that acts as carrier and the final product formulation.

The developed chocolate milk dessert enriched with an antioxidant extract from *Achyrocline satureoides* performed better among Uruguayan consumers, and can be an alternative for Uruguayan dairy companies to launch in the market differential products with added-value, contributing to improving the health status of the population.

Moreover, further research is necessary in order to study the bioavailability of polyphenolic compounds in the developed milk dessert, particularly due to the potential interaction between polyphenols and milk. Also, clinical studies should be performed to investigate if the consumption of this dessert has a positive influence on health.

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APPENDIXES

APPENDIX A. List of items included in the Food Choice Questionnaire developed by Steptoe *et al.* (1995)

1. Is easy to prepare
2. Contains no additives
3. Is low in calories
4. Tastes good
5. Contains natural ingredients
6. Is not expensive
7. Is low in fat
8. Is familiar
9. Is high in fibre and roughage
10. Is nutritious
11. Is easily available in shops and supermarkets
12. Is good value for money
13. Cheers me up
14. Smells nice
15. Can be cooked very simply
16. Helps me cope with stress
17. Helps me control my weight
18. Has a pleasant texture
19. Is packaged in an environmentally friendly way
20. Comes from countries I approve of politically
21. Is like the food I ate when I was a child
22. Contains a lot of vitamins and minerals
23. Contains no artificial ingredients
24. Keeps me awake/alert
25. Looks nice
26. Helps me relax
27. Is high in protein
28. Takes no time to prepare
29. Keeps me healthy
30. Is good for my skin/teeth/hair/nails etc
31. Makes me feel good
32. Has the country of origin clearly marked
33. Is what I usually eat
34. Helps me to cope with life
35. Can be bought in shops close to where I live or work
36. Is cheap

APPENDIX B. Food choice and food frequency consumption questionnaire used in Chapter 1.

QUESTIONNAIRE

Gender			Age			
Education	Primary school		Secondary school		University	
Marital status						
Number of adults living with you		Number of children living with you				

It is important to me that the food I eat everyday…								
Is easy to prepare	Not at all important ☐	☐	☐	☐	☐	☐	☐ Very important
Contains a high nutritional value	Not at all important ☐	☐	☐	☐	☐	☐	☐ Very important
Contains a lot of vitamins and minerals	Not at all important ☐	☐	☐	☐	☐	☐	☐ Very important
Contains no additives	Not at all important ☐	☐	☐	☐	☐	☐	☐ Very important
Tastes good	Not at all important ☐	☐	☐	☐	☐	☐	☐ Very important
Makes me feel safe and trusty	Not at all important ☐	☐	☐	☐	☐	☐	☐ Very important
Makes me feel good	Not at all important ☐	☐	☐	☐	☐	☐	☐ Very important
Keeps me healthy	Not at all important ☐	☐	☐	☐	☐	☐	☐ Very important
Is not expensive	Not at all important ☐	☐	☐	☐	☐	☐	☐ Very important
Contains no artificial ingredients	Not at all important ☐	☐	☐	☐	☐	☐	☐ Very important
Helps me control my weight	Not at all important ☐	☐	☐	☐	☐	☐	☐ Very important
Has a long shelf life	Not at all important ☐	☐	☐	☐	☐	☐	☐ Very important
is low in fat	Not at all important ☐	☐	☐	☐	☐	☐	☐ Very important
Is high in protein	Not at all important ☐	☐	☐	☐	☐	☐	☐ Very important
Looks nice	Not at all important ☐	☐	☐	☐	☐	☐	☐ Very important

It is important to me that the food I eat everyday…							
Is familiar	☐ Not at all important	☐	☐	☐	☐	☐	☐ Very important
Is made in Uruguay	☐ Not at all important	☐	☐	☐	☐	☐	☐ Very important
Is low in calories	☐ Not at all important	☐	☐	☐	☐	☐	☐ Very important
Is from a well known brand	☐ Not at all important	☐	☐	☐	☐	☐	☐ Very important
Contains natural ingredients	☐ Not at all important	☐	☐	☐	☐	☐	☐ Very important
Is easily available in shops and supermarkets	☐ Not at all important	☐	☐	☐	☐	☐	☐ Very important
Has a pleasant texture	☐ Not at all important	☐	☐	☐	☐	☐	☐ Very important

Please indicate the frequency in which you consume each of the food categroies that are indicated bellow.

Food category	***One or more times a day***	***Four to six times a week***	***Two to three times a week***	***One or less times a week***
Fruits				
Vegetables				
Milk and dairy products				
Meat and meat products				
Fish and seafood				
Cereals and bakery				
Whole cereals products				
Fatty food (fried food, mayonnaise, oils, etc.)				
Sugary foods (sweets, marmalades, etc.)				

APPENDIX C. Questionnaire on functional foods' perception used in Chapter 2.

QUESTIONNAIRE

Gender			Age		
Education	Primary school		Secondary school		University	
Marital status					
Number of adults living with you			Number of children living with you		

Have you ever heard the term 'functional foods'?			
Yes		No	

What do you think a "functional food" is?

How important is for you the impact on your health of each of the following factors?	
Regular exercise	☐ ☐ ☐ ☐ ☐ ☐ ☐ Not at all important … Very important
Avoid smoking	☐ ☐ ☐ ☐ ☐ ☐ ☐ Not at all important … Very important
Genetic	☐ ☐ ☐ ☐ ☐ ☐ ☐ Not at all important … Very important
Avoid stress	☐ ☐ ☐ ☐ ☐ ☐ ☐ Not at all important … Very important
Avoid drinking alcohol	☐ ☐ ☐ ☐ ☐ ☐ ☐ Not at all important … Very important
Wholesome and varied diet	☐ ☐ ☐ ☐ ☐ ☐ ☐ Not at all important … Very important

How frequently do you read the following information on the label of the food you purchase?			
	Always	***Sometimes***	***Never***
Net weight			
Shelf life			
List of ingredients			
Nutritional information			
Country of origin			

Do you believe that certain kinds of food could have a positive impact on your health?			
Yes		**No**	

Would you regularly buy and consume that kind of foods?			
Yes		**No**	

Please indicate less a maximum of three health aspects or diseases you would prefer a food to prevent or have a positive influence	
Cardiovascular deseases	
Lower cholesterol	
Lower blood pressure	
Prevent osteoporosis	
Prevent cancer	
Enhance immune system	
Slimming effect	
Increase healthy gut bacteria	

APPENDIX D. Attitudinal questionnaire used in Section 2.3 to identify consumers with different interests and concerns on health and nutrition.

Please indicate your degree of agreement with each of the following statements	
1. Diet is important for my health	☐ ☐ ☐ ☐ ☐ ☐ ☐ I completely disagree … I completely agree
2. Consuming some food products could have a positive impact on my health	☐ ☐ ☐ ☐ ☐ ☐ ☐ I completely disagree … I completely agree
3. Consuming some food products could help preventing some diseases	☐ ☐ ☐ ☐ ☐ ☐ ☐ I completely disagree … I completely agree
4. I do all I can to keep myself healthy	☐ ☐ ☐ ☐ ☐ ☐ ☐ I completely disagree … I completely agree
5. I am willing to make sacrifices to keep myself healthy	☐ ☐ ☐ ☐ ☐ ☐ ☐ I completely disagree … I completely agree
6. I am interested in taking measures for preventing the occurrence of some diseases	☐ ☐ ☐ ☐ ☐ ☐ ☐ I completely disagree … I completely agree
7. I am interested in losing weight	☐ ☐ ☐ ☐ ☐ ☐ ☐ I completely disagree … I completely agree
8. High fat intake could increase the risk of some diseases	☐ ☐ ☐ ☐ ☐ ☐ ☐ I completely disagree … I completely agree
9. High fibre intake could decrease the risk of some diseases	☐ ☐ ☐ ☐ ☐ ☐ ☐ I completely disagree … I completely agree
10. Antioxidants intake could decrease the risk of some diseases	☐ ☐ ☐ ☐ ☐ ☐ ☐ I completely disagree … I completely agree
11. Healthiness and nutritional content have a high impact on my food choices	☐ ☐ ☐ ☐ ☐ ☐ ☐ I completely disagree … I completely agree
12. I always follow a healthy and balanced diet	☐ ☐ ☐ ☐ ☐ ☐ ☐ I completely disagree … I completely agree
13. I am willing to consume products that have a positive impact on my health	☐ ☐ ☐ ☐ ☐ ☐ ☐ I completely disagree … I completely agree
14. I am interested in consuming products that have a positive impact on my health even if I don't like them as much as others	☐ ☐ ☐ ☐ ☐ ☐ ☐ I completely disagree … I completely agree
15. I am interested in consuming products with low-calorie content	☐ ☐ ☐ ☐ ☐ ☐ ☐ I completely disagree … I completely agree
16. I am interested in consuming products with low-fat content	☐ ☐ ☐ ☐ ☐ ☐ ☐ I completely disagree … I completely agree

APPENDIX E. Nutritional Knowledge Questionnaire. The questionnaire was divided in three sections: (i) experts' recommendations regarding healthy eating (questions 1-3), (ii) knowledge about the nutrient content of different foods (questions 4-15), (iii) knowledge about antioxidants (questions 16-18) and (iv) knowledge about links between diet and diseases (questions 19-28).

1. Do you think nutritionists and doctors recommend that people should be eating more, the same amount or less of these foods? *Please tick only one box per food*

	More	**The same**	**Less**	**Not sure**
Vegetables	---	---	---	---
Sugary foods	---	---	---	---
Meet	---	---	---	---
Cereals and Bakery	---	---	---	---
Fatty foods	---	---	---	---
High fibre foods	---	---	---	---
Fruits	---	---	---	---
Salty foods	---	---	---	---

2. How many servings of fruit and vegetables a day do you think experts are advising people to eat? *(one serving could be, for example, an orange or a handful of chopped carrots)*

3. Which fat do experts say is most important for people to cut down of? *Please tick only one box*

Saturated fat	**Monounsaturated fat**	**Polyunsaturated fat**	**Not sure**
---	---	---	---

4. Do you think that these foods are high or low in sugar? *Please tick only one box*

	High	**Low**	**Not sure**
Bananas	---	---	---
Plain yogurt	---	---	---
Ice cream	---	---	---
Orange juice	---	---	---
Tomato ketchup	---	---	---
Canned peaches	---	---	---
Bread	---	---	---

5. Do you think that these foods are high or low in fat? *Please tick only one box*			
	High	**Low**	**Not sure**
Mayonnaise	---	---	---
Beans	---	---	---
Red meat	---	---	---
Money	---	---	---
Scotch egg	---	---	---
Nuts	---	---	---
Bread	---	---	---
Cottage cheese	---	---	---
Margarina	---	---	---

6. Do you think that these foods are high or low in starch? *Please tick only one box*			
	High	**Low**	**Not sure**
Cheese	---	---	---
Pasta	---	---	---
Butter	---	---	---
Nuts	---	---	---
Rice	---	---	---
Apple	---	---	---
Bread	---	---	---

7. Do you think that these foods are high or low in salt? *Please tick only one box*			
	High	**Low**	**Not sure**
Ham	---	---	---
Pasta	---	---	---
Potato chips	---	---	---
Red meat	---	---	---
Vegetables	---	---	---
Cheese	---	---	---

8. Do you think that these foods are high or low in proteins? *Please tick only one box*			
	High	**Low**	**Not sure**
Fish	---	---	---
Chicken	---	---	---
Fruits	---	---	---
Baked beans	---	---	---
Butter	---	---	---
Whipped cream	---	---	---
Mushrooms	---	---	---

9. Do you think that these foods are high or low in fibre? *Please tick only one box*			
	High	**Low**	**Not sure**
Breakfast cereals	---	---	---
Banana	---	---	---
Eggs	---	---	---
Red meat	---	---	---
Broccoli	---	---	---
Nuts	---	---	---
Spinach	---	---	---
Bread	---	---	---
Chicken	---	---	---
Baked beans	---	---	---
Brown rice	---	---	---
Mushrooms	---	---	---

10. Some foods contain a lot of fat but no cholesterol

True	False	Not sure
---	---	---

11. There is more calcium in a glass of whole milk than in a glass of skimmed milk

True	False	Not sure
---	---	---

12. There is more protein in a glass of whole milk than in a glass of skimmed milk

True	False	Not sure
---	---	---

13. Margarine contains less fat than butter

True	False	Not sure
---	---	---

14. Which of the following breads contain more vitamins and minerals? *Tick only one box*

White bread	Brown bread	Wholegrain	Not sure
---	---	---	---

15. Which of the following has the most calories for the same weight? *Tick only one box*

Sugar	Starch	Fibre	Fat	Not sure
---	---	---	---	---

16. Have you heard about antioxidants?

Yes	No
---	---

17. If you answer 'Yes' to the previous question, which of the following substances do you think that are antioxidants? *Tick only one box*			
	Yes	**No**	**Not sure**
Vitamin A	---	---	---
Vitamin C	---	---	---
β-glucans	---	---	---
Polyphenols	---	---	---
Flavonoids	---	---	---
Clorofyl	---	---	---
Vitamin D	---	---	---

18. Do you think that the following food products contain antioxidants?			
	Yes	**No**	**Not sure**
Hamburguers	---	---	---
Wine	---	---	---
Tea	---	---	---
Broccoli	---	---	---
Strawberries	---	---	---
Milk	---	---	---
Mushrooms	---	---	---

19. Are you aware of any major health problems or diseases that are related to a low intake of fruits and vegetables?		
Yes	**No**	**Not sure**
---	---	---
20. If yes, what do you think that these diseases or health problems are?		

21. Are you aware of any major health problems or diseases that are related to a low intake of fibre?		
Yes	**No**	**Not sure**
---	---	---
22. If yes, what do you think that these diseases or health problems are?		

23. Are you aware of any major health problems or diseases that are related to how much sugar people eat?		
Yes	**No**	**Not sure**
---	---	---
24. If yes, what do you think that these diseases or health problems are?		

25. Are you aware of any major health problems or diseases that are related to the amount of fat people eat?		
Yes	**No**	**Not sure**
---	---	---
26. If yes, what do you think that these diseases or health problems are?		

27. Do you think these help to reduce the chances of getting certain kinds of cancer? *Answer each one*

	Yes	No	Not sure
Eating more fibre	---	---	---
Eating less sugar	---	---	---
Eating less fruits	---	---	---
Eating less salt	---	---	---
Eating more fruits and vegetables	---	---	---
Eating less presevatives	---	---	---
Eating more antioxidants	---	---	---

28. Do you think these help to reduce the chances of prevent cardiovascular diseases? *Answer each one*

	Yes	No	Not sure
Eating more fibre	---	---	---
Eating less saturated fat	---	---	---
Eating less salt	---	---	---
Eating more fruits and vegetables	---	---	---
Eating less preservatives	---	---	---
Eating more antioxidants	---	---	---

APPENDIX F. Attitudinal questionnaire about health and hedonic characteristics of foods used in Section 3.4.

Please indicate your degree of agreement with each of the following statements							
1. Diet is important for my health	☐ I completely disagree	☐	☐	☐	☐	☐	☐ I completely agree
2. I always eat food products that I like	☐ I completely disagree	☐	☐	☐	☐	☐	☐ I completely agree
3. Consuming some food products could have a positive impact on my health	☐ I completely disagree	☐	☐	☐	☐	☐	☐ I completely agree
4. Consuming certain food products could help preventing some diseases	☐ I completely disagree	☐	☐	☐	☐	☐	☐ I completely agree
5. Food products should not necessarily be a source of pleasure	☐ I completely disagree	☐	☐	☐	☐	☐	☐ I completely agree
6. I do all I can to keep myself healthy	☐ I completely disagree	☐	☐	☐	☐	☐	☐ I completely agree
7. I am willing to make sacrifices to keep myself healthy	☐ I completely disagree	☐	☐	☐	☐	☐	☐ I completely agree
8. I am interested in taking measures for preventing the occurrence of some diseases	☐ I completely disagree	☐	☐	☐	☐	☐	☐ I completely agree
9. I do not take into account the appearance of food when deciding what to eat	☐ I completely disagree	☐	☐	☐	☐	☐	☐ I completely agree
10. Food products should have a taste that I like	☐ I completely disagree	☐	☐	☐	☐	☐	☐ I completely agree
11. I am interested in losing weight	☐ I completely disagree	☐	☐	☐	☐	☐	☐ I completely agree
12. I am interested in enjoying the taste of foods	☐ I completely disagree	☐	☐	☐	☐	☐	☐ I completely agree
13. High fibre intake could decrease the risk of some diseases	☐ I completely disagree	☐	☐	☐	☐	☐	☐ I completely agree
14. Antioxidants intake could decrease the risk of some diseases	☐ I completely disagree	☐	☐	☐	☐	☐	☐ I completely agree
15. Food products should have a taste that I like	☐ I completely disagree	☐	☐	☐	☐	☐	☐ I completely agree
16. Healthiness and nutritional content have a high impact on my food choices	☐ I completely disagree	☐	☐	☐	☐	☐	☐ I completely agree
17. I always follow a healthy and balanced diet	☐ I completely disagree	☐	☐	☐	☐	☐	☐ I completely agree
18. I am willing to consume products that have a positive impact on my health	☐ I completely disagree	☐	☐	☐	☐	☐	☐ I completely agree
19. I am interested in consuming products that have a positive impact on my health even if I don't like them as much as others	☐ I completely disagree	☐	☐	☐	☐	☐	☐ I completely agree
20. I consume highly nutritious products that I don\`t like	☐ I completely disagree	☐	☐	☐	☐	☐	☐ I completely agree

APPENDIX G. Evaluation sheet used in the projective mapping task carried out in Section 5.2 for evaluating consumers' perception of chocolate milk desserts.

EVALUATION SHEET

Gender____________ Age___________

INSTRUCTIONS

- You will be asked to try 8 **CHOCOLATE MILK DESSERTS**.
- You will have to evaluate the similarities and differences between the desserts.
- First, try each of the desserts, trying to remember their sensory characteristics. Please, write down up to four words to describe each of the desserts in the space provided.
- After trying all the desserts you have to place them in the separate sheet provided, according to the similarities and dissimilarities between them. You have to place the samples considering that two samples close together on the sheet correspond to very similar samples; whereas two samples that are very different have to be located ery distant from each other.
- You have to complete the task according to your own criteria. There are no right or wrong answers.

Sample Nº ________

____

Sample Nº ________

____

Sample Nº ________

____

APPENDIX H. Evaluation sheet used in Section 5.2 for evaluating consumers' perception of chocolate milk desserts using a check-all-that-apply question.

EVALUATION SHEET

Gender______________ Age ________

INSTRUCTIONS:

- You will be asked to try 8 samples of **CHOCOLATE MILK DESSERTS.**
- Please, try the first sample indicated in the evaluation sheet and answer each of the questions.
- Please, drink some water and follow with the following samples.

Sample N°______

¿How much do you like this dessert? ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Dislike very much … **Like very much**

Please, check all the words you think that apply to this dessert:

Sweet	☐	Not much sweet	☐
Yummy	☐	Disgusting	☐
Soft	☐	Very thick	☐
Thick	☐	Very sweet	☐
Intense chocolate flavour	☐	Not much thick	☐
Vanilla flavour	☐	Not much chocolate flavour	☐
Creamy	☐	Bitter	☐
Delicious	☐	Not much creamy	☐
Rough	☐		

APPENDIX I. Evaluation sheet used in Section 5.3 for evaluating consumers' perception of chocolate milk desserts using a check-all-that-apply question.

EVALUATION SHEET

Gender______________ Age ________

INSTRUCTIONS:

- You will be asked to try 9 samples of **CHOCOLATE MILK DESSERTS.**
- Please, try the first sample indicated in the evaluation sheet and answer each of the questions.
- Please, drink some water and follow with the following samples.

Sample N°______

¿How much do you like this dessert? ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Dislike very much … **Like very much**

Please, check all the words you think that apply to this dessert:

Sweet	☐	Not much sweet	☐
Yummy	☐	Disgusting	☐
Soft	☐	Very thick	☐
Thick	☐	Very sweet	☐
Intense chocolate flavour	☐	Not much thick	☐
Vanilla flavour	☐	Not much chocolate flavour	☐
Very Creamy	☐	Bitter	☐
Delicious	☐	Not much creamy	☐
Rough	☐	Creamy	☐

APPENDIX J. Evaluation sheet used in Chapter 6 for evaluating consumers' expectations and perception of chocolate milk desserts enriched with antioxidants.

EVALUATION SHEET (I)

Name___________________ Age ________

Imagine a chocolate milk dessert enriched with antioxidants

How much do you think you would like it?	☐ **Dislike very much**	☐	☐	☐	☐	☐	☐	☐	☐ **Like very much**
Would you purchase this type of dessert?	☐ **Definitively NO**	☐	☐	☐	☐	☐	☐	☐	☐ **Definitively YES**

Please write down the first 4 images, words, associations, thoughts or feelings that come to your maind when thinking of a CHOCOLATE MILK DESSERT ENRICHED WITH ANTIOXIDANTS____
____
____

EVALUATION SHEET (II)

Name___________________

INSTRUCTIONS:

- You are going to evaluate a regular chocolate milk dessert and five chocolate milk desserts enriched with antioxidants
- Please try the first sample, starting by the one located at your left, and answer the questions.
- Rinse your mouth with water and continue with the following simples.

Sample N° _______

How much do you like this dessert?	☐ **Dislike very much**	☐	☐	☐	☐	☐	☐	☐	☐ **Like very much**
Would you purchase this dessert?	☐ **Definitively NO**	☐	☐	☐	☐	☐	☐	☐	☐ **Definitively YES**

Please write down up to 4 words to describe this dessert________
____

……………………………………………………………………………..

Which of the six desserts would you buy? __________________